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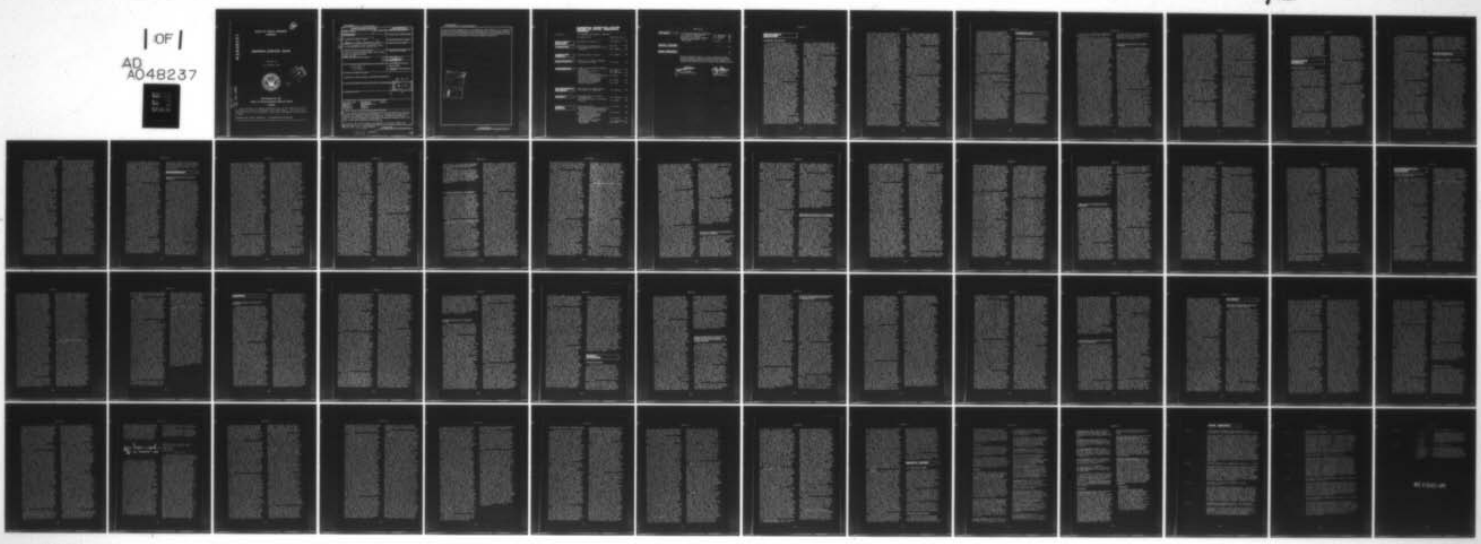

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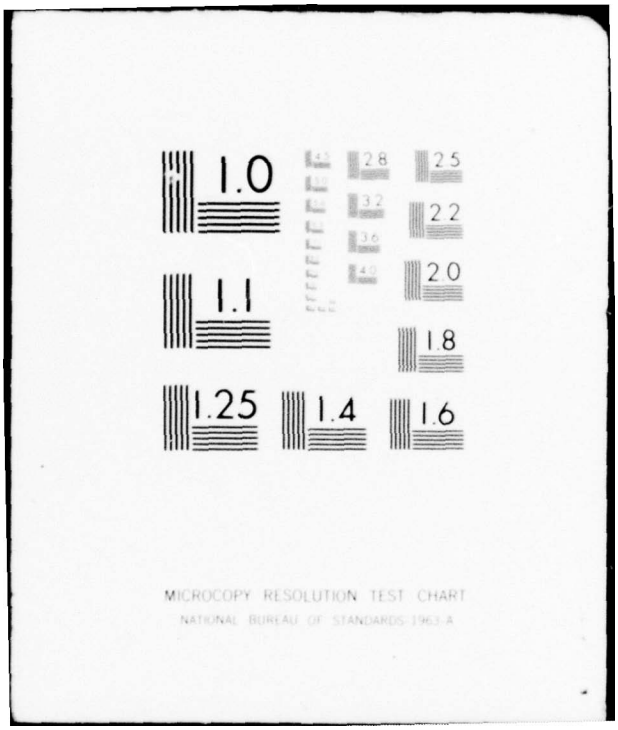
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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

The articles are written primarily by members of the staff of ONRL, with

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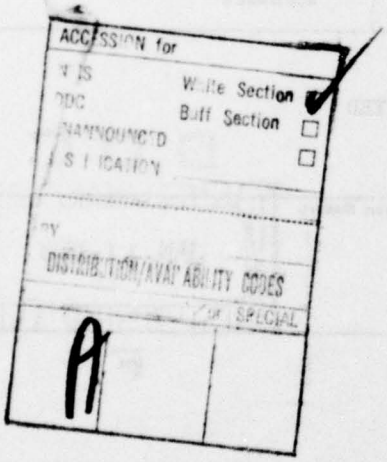

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OFFICE OF NAVAL RESEARCH
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Edited by J.B. Bateman and Victoria S. Hewitson

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BEHAVIORAL SCIENCES

BIOFEEDBACK AND BEHAVIOR

The Max Planck Institut für Psychiatrie, Munich, Germany, was the site of a most interesting NATO Symposium during the period 27-30 July. The conference, which was co-sponsored by ONR, was attended by 80 persons from 10 countries. The co-directors of the Symposium, Dr. Jackson Beatty (University of California, Los Angeles) and Prof. Heiner Legewie (Max Planck Institut für Psychiatrie, Munich) stated that the purpose of the meeting was to "explore both theoretical and applied issues arising from the use of biofeedback procedures for the control of visceral, central nervous system and skeletal events." Because this is a relatively new field of investigation, an effort was made to introduce the subject to the uninitiated as well as to afford an opportunity for specialists in the field to discuss recent research. The meeting was well organized, and the fact that a complete set of preprints was distributed helped to ensure that a maximum exchange of information and understanding occurred.

Biofeedback, as an area of investigation, began in the 1960s as a result of the research of five individuals, according to A.H. Black (McMaster University), who gave the opening address. While the interests of these five scientists ranged from studying complex psychological states to basic neurophysiology, there were two common threads which ran through the work of each. First, the responses which were studied could not be observed directly by the experimenter or by the subject himself; thus, some device had to be employed to record and display them. Secondly, the goal of the research was to change the probability of the response occurring and to produce a stimulus which the subject could observe contingent upon, and hence associated with, the response. Thus, biofeedback control is the ability to control responses that cannot be directly observed.

Because of the mystique that unfortunately was associated with the concept of biofeedback in the late '60s and early '70s, many scientists chose not to "become involved" in research on the subject. Other problems which discouraged careful investigations were the difficulty in replicating some of the early studies and the suggestion by some well-meaning, but misguided, psychologists that control of cortical electrical activity implied the control of certain psychological states in human subjects.

Before going further, perhaps a brief example of a biofeedback experiment is in order. Let's say that the goal of a particular study is to reduce the heart rate by using biofeedback. The subject might be asked to sit or lie down in a quiet, darkened room and relax. The necessary electrodes would be attached to record the heart rate and the subject furnished with a set of earphones. Each time the heart rate decreased below a preselected criterion the subject would hear a tone in his headset. After a period of training the subject would presumably learn to associate certain feelings or sensations with the onset of the tone (which was always paired with the decreased heart rate) and hence be able "voluntarily" to reduce the heart rate, even later when the tone was not presented.

As Black pointed out, what on the surface appears to be a simple learning task is really a situation fraught with complications; e.g., what is really being learned, what is meant by voluntary, what are the variables, and what response should be reinforced in order to achieve a particular therapeutic effect?

The session relating to learned control of central nervous system activity was opened by Dr. L.C. Johnson (Naval Health Research Center, San Diego) who reviewed the evidence pertaining to the voluntary control of cortical activity. He pointed out that there are many reports which claim that feedback control of alpha (electrical) rhythms in the brain has been demonstrated. Most of these reports, however, are not based on carefully controlled experiments. As the evidence trickled in during the early '70s based on well-designed

experiments, more and more doubt arose as to the validity of the earlier studies. Johnson stated that "...the results are sufficient to justify the conclusion that unmediated learned control of alpha activity *per se* has not been achieved." He went on to say that "other workers have concluded that alpha activity is mediated by a whole host of factors, and the likelihood of ever controlling or eliminating all these factors to observe only simple alpha conditioning is extremely small. Thus, in the more restricted sense, any discussion of the operant control of alpha activity seems operationally indefensible." He also addressed the claim that there are psychological benefits accruing from alpha control. Again, according to Johnson, controlled experimentation has not provided supporting evidence for this, and in those cases where a positive psychological experience occurred, the results were influenced by subject and experimenter expectations and by the instructions given to the subject. The basis for some of these earlier claims was, in part, the fact that certain individuals could achieve a "high" without drugs. This had sufficient appeal for some experimenters to get carried away and they tended to ignore hard evidence.

The series of papers that followed addressed several issues relating to the underlying mechanisms and the subjective experience of an enhanced alpha state (a condition in which the subject is relaxed, serene and generally has an absence of thought). W.B. Plotkin (University of Colorado) felt that his data, based on alpha feedback experiments with 48 subjects, demonstrated that even though the subjective experiences of some subjects may be unrelated to specific changes in the alpha the experience and feelings produced during the experimental sessions were of great personal value in themselves.

The situation with regard to the biofeedback control of the theta cortical activity is even less clear. The basic tenet is that the suppression of occipital theta activity will tend to maintain or increase alertness. N. Birbaumer (University of Tübingen) conducted experiments which led him to conclude that "...the self-control of theta is very specific and is not influenced by the self-regulation of other physiological functions and that the practical usefulness of theta biofeedback remains to be demonstrated." J.F. O'Hanlon (Human Factors Research Inc., Santa Barbara), on the other hand, conducted experiments using 80 subjects which "...demonstrated the beneficial effect of theta suppression on the (signal detection) performance of college students and professional radar operators...." Thus the controversy continues.

In the session on Visceral Learning, an interesting presentation was made by A.H. Harris (Johns Hopkins University) who described production of cardiovascular changes (increased blood pressure) in baboons using biofeedback. Basically the baboons were required to maintain prespecified diastolic blood pressure levels in order to obtain food and avoid electric shock. In the course of a two- to three-month training period seven baboons attained diastolic blood pressure levels approximately 33% above baseline values. In these experiments, the biofeedback was in the form of two lights. A white light went on each time the blood pressure exceeded the criterion and a red light went on each time it went below.

A fascinating study was reported by T.G. Pickering (Radcliffe Infirmary, Oxford) in which significant changes in blood pressure were induced using biofeedback in eight patients suffering from complete neuromuscular paralysis. The study was performed in order to eliminate the influence of the contraction of small muscles which are known to be capable of producing an elevated blood pressure. The investigators were surprised to learn that an attempted contraction of an atrophied muscle by four of the patients, whose condition was a result of polio or muscular dystrophy, could result in a sizable rise of blood pressure and heart rate. It was suggested by the investigators that the mental activity itself involved in the attempted contraction may have been partly responsible for the cardiovascular changes. In the four patients suffering from a complete spinal cord transection at the cervical level, three were able to increase arterial pressure and all four were able to raise their heart rates. In this instance the investigators felt that the patients were effecting the changes through vagal control.

When dealing with normal subjects, it often is difficult to demonstrate that results attributed to biofeedback

training are due to the biofeedback or to the relaxing environment of a comfortable, darkened laboratory room. Further, in spite of the fact that laboratory investigations have yielded data showing that biofeedback can produce biological changes under controlled conditions, many at the meeting were concerned about the paucity of evidence demonstrating that similar changes can be transferred outside the laboratory. Although at least one presentation cited evidence of theta control in an applied setting, more work needs to be done in the no-man's land between the laboratory and the field.

The therapeutic value of biofeedback was also a matter of some controversy. While many have hopes of using biofeedback in the future for treatment of various disorders, data showing its value are sorely needed. According to B.T. Engel (National Institute of Aging, Baltimore), there is insufficient evidence to evaluate the therapeutic effectiveness of biofeedback either as a primary or adjunctive therapy for cardiovascular disorders at the present time.

Other presentations addressed issues such as visceral feedback and taste, the regulation of psychological processes, feedback strategies in neuromuscular disorders, and various basic methodological problems.

This conference was intended to be a critical review of an area of science with only a 10-year history. In the writer's opinion this objective was fulfilled. The field has evolved from a rather sensational, perhaps even an emotional, beginning into one where hard questions are being asked and experimental rigor is being increased. To quote Beatty in his closing remarks: "One does not sense the approach of a major scientific discovery, but rather a productive period of normal science." Legewie in his concluding remarks reminded the group that in the mid-sixties when the biofeedback movement began "...many of us believed we were on the right path to a new key paradigm for explaining and treating psychosomatic disorders." He now feels that such hopes have proven false and that the proper approach is to consider biofeedback as one technique among many for use in the treatment of psychosomatic disorders. (J.W. Miller)

CHEMISTRY

MACROMOLECULAR NOMENCLATURE

The International Union of Pure and Applied Chemistry (IUPAC), among its many activities, sponsors Commissions on the nomenclature of each of the major disciplinary areas in chemistry. One of these Commissions, that on macromolecular nomenclature, held its annual meeting in Dorking, England, in June 1976. The Commission began its work in 1968 and has been chaired from its inception by Dr. Kurt Loening, Director of Nomenclature for the Chemical Abstracts Service (Columbus, Ohio 43210, USA). Each of the Commission members is a specialist and has long experience in some field of macromolecular science such as synthesis, microstructure, or supramolecular structure of polymers; all of the members have had extended experience in nomenclature work. Six major languages and both industry and academia are represented on the Commission.

Recent reports of the Commission include a list of abbreviations for synthetic polymers and polymeric materials [*Pure and Applied Chem.* 40, No. 3, 475-6 (1974)] and a document [*ibid.* 479-91] concerned with definitions relating to polymers. Each of the definitions derives from primary structure-based definitions of "polymer" and "constitutional unit" and related secondary process-based definitions of "monomer" and "polymerization".

A previously published tentative proposal for a structure-based nomenclature for regular single-strand polymers was completed at the Dorking meeting; this document will appear in *Pure and Applied Chemistry* in the near future. Conventional nomenclature is based on the name of the monomer; this system leads to ambiguity as in the two possible "poly(4-vinylbenzaldehyde)" polymers. The structure-based nomenclature consists of a set of rules through which the chemical repeating unit of a regular polymer is defined and named by established IUPAC organic nomenclature rules. The two polymers derived from 4-vinylbenzaldehyde would be named "poly[(4-formylphenyl)ethylene]" and "poly[oxy-(4-vinylphenyl)methylene]"

by this system. This basic nomenclature is now used in Chemical Abstracts indexes (q.v.).

Major functions of the Commission include review of nomenclature proposals submitted by national committees and the development of nomenclature by the Commission itself. The structure-based nomenclature and a proposal for inorganic polymer nomenclature, considered at Dorking, were generated by the Polymer Division Nomenclature Committee of the American Chemical Society; the document on inorganic polymer nomenclature will also be reviewed by the IUPAC Commission on Inorganic Nomenclature. Much of the Dorking meeting was devoted to Commission-generated stereochemical definitions and nomenclature related to polymers, under the general direction of Prof. P. Corradini (University of Naples). A report in this area is nearing completion. The Commission is also developing nomenclature for copolymers under the direction of Dr. W. Ring (Chemische Werke Hüls, Marl, W. Germany) and a polymer classification system under the direction of Prof. N. Platé (University of Moscow). The copolymer nomenclature will be patterned in part after a system for polypeptides adopted by the International Union of Biochemistry. Among other items considered at Dorking, the Commission recommended that use of the term "molecular weight" be abandoned in favor of the IUPAC-recommended "relative molecular mass" and that the latter term be used with "number-average" and similar terms in the polymer field.

In a sense, the Commission and the national nomenclature committees that contribute to it are conducting research and development in chemical communication. The products of these groups require a long period to reach maturity, and, once mature, they still must be voluntarily adopted by the scientific community for use in the technical literature and other forms of communication. The basic definition document of the Commission was six years in the making. Work on the structure-based nomenclature began in 1964; it can now be found in the indexes of *Chemical Abstracts* and in the pages of many polymer journals. Problems, new ideas, and critical comment are immensely important in this type of effort, for language itself is affected through the instillation of precise thought processes by way of definitions and the manner in which materials are regarded by the scientific community. Those interested in these areas are invited to communicate directly with the Commission Chairman. (R.B. Fox, Naval Research Laboratory, Washington, DC)

THE INTERNATIONAL MEETING ON BORON CHEMISTRY

The Third International Meeting on Boron Chemistry (IMEBORON) was held in Munich and Ettal, FRG, 5 to 9 July 1976. This occasion represented the continuation of a "tradition" which began in 1971 with the first IMEBORON meeting in Czechoslovakia, followed by IMEBORON II in Leeds, England, in 1974. The highlights of the opening session at the University of Munich were the award of the Alfred Stock Medal of the Gesellschaft Deutscher Chemiker to Professor Heinz Nöth, a lecture by Professor Wiberg on "Alfred Stock and the Renaissance of Inorganic Chemistry," the award of an honorary degree from the University of Munich to William N. Lipscomb (a very rare honor; the last was given four years ago to Ernst Fischer, recent Nobel laureate), and Lipscomb's lecture on structure and bonding in boron hydrides. The thrust of Lipscomb's talk was his refinement of the valence bond theory of boranes to include partial 3-center bonding, which provides a theoretical basis for many observed distortions in borane structures.

In the afternoon the participants, wives and guests traveled to the resort village of Ettal in the foothills of the Bavarian Alps, where the IMEBORON meeting continued. The nationalities represented were primarily American, West German, Russian, and British, with smaller groups from Czechoslovakia, France, Japan, Algeria, Belgium, Norway, Switzerland, and Canada. Although the majority were from academic institutions, there was a sizable representation from industry. Ten plenary and section lectures and some 42 contributed papers were presented, most of which were of high caliber. The general feeling was that the meeting was highly successful.

Some of the particularly significant reports are summarized here. Sheldon Shore (Ohio State) gave an elegant plenary lecture describing high-yield, large-scale preparations of B_5H_{11}, B_6H_{10}, and B_6H_{12}, outlining the addition of protons and metal ions

to basic sites in boranes, and discussing the structure of a new ferraborane, $B_5H_9Fe(CO)_3$, derived from B_6H_{10}. J.B. Leach (Oxford Polytechnic) reported on work with Tom Onak (Cal. State, Los Angeles), in which the B_5H_8 group in derivatives such as $Me_2(ClCH_2)$-SiB_5H_8 migrates from silicon to carbon in the presence of $AlCl_3$. Malcolm Wallbridge (Warwick) described the synthesis and structures of several novel aluminaboranes, e.g. , $B_3H_8Al(BH_4)_2$, in which an $Al(BH_4)_2$ unit replaces a BH_2 group in B_4H_{10}. W. Buchner (Bayer A. G.) discussed the industrial use of borohydride salts as organic and inorganic reducing agents in chemical nickel plating, and other applications. E.A. Sullivan (Ventron Corporation, Beverly, Mass.) gave an interesting paper on the industrial removal and recovery of metals with $NaBH_4$; by this method, mercury in 10-50 ppm concentration can be reduced to <10 parts per billion; lead and silver can also be recovered (as free metals) in high efficiency. The technique is being applied industrially to efficient streams for removal of mercury at chlor-alkali plants and lead at tetraethyl lead manufacturing sites. Ag, Rh, and Cu are being recovered commercially for re-use.

M. Kyrs (Institute of Inorganic Chemistry, Prague) discussed a novel application of metalloboranes involving the use of $[(C_2B_9H_{11})_2Co]^-$ ion as a liquid cation exchanger. The large metalloborane cations have a very strong tendency to pass from aqueous phases into organic solvents, and possess several other advantages enabling heavy metals to be extracted from acid solutions. G.G. Zhigareva (Moscow) reported on the neurotropic activity and therapeutic range of amino-substituted carboranes.

Professor Nöth (Univ. of Munich) described the synthesis of boranes and other boron compounds in an IR laser; the reactions are laser-specific and differ considerably from thermal processes. Several papers dealing with the synthesis of novel boron-nitrogen ring systems were presented, notably by K. Niedenzu (Kentucky), P. Paetzold (Aachen), W. Storch (Munich), and B. Frange (Faculty of Sciences, Algiers).

Several of the German groups reported some fascinating new monoboron clusters which are directly and closely related to metalloboranes and metallocarboranes, yet are derived from organoboranes. Thus, in his plenary lecture G.E. Herberich (Aachen) described the synthesis and x-ray study of $(CO)_3Mn(C_6H_5BC_4H_4)Mn(CO)_3$, a triple-decker species which is isoelectronic with the $Cp_2Co_2C_2B_3H_5$ triple-decker sandwiches (where Cp stands for cyclopentadienyl, C_5H_5) previously reported by the University of Virginia group, and contains a central planar C_4B ring. Other metal complexes featuring C_4B, C_5B, or C_6B rings coordinated to a metal atom were also reported by Herberich, e.g., $[C_5H_5BR]_2Fe$, an analog of ferrocene containing two C_5B planar rings. Kinberger and Siebert (Marburg) reported some novel complexes containing a planar C_2B_2S ring, such as $(CO)_3Mn[(CH_3)_2B_2C_2(C_2H_5)_2S]Mn(CO)_3$ and $CpFe[(CH_3)_2B_2C_2(C_2H_5)_2S]FeCp$, again triple-decker sandwiches analogous to ours. These and many other new monoboron cluster compounds reported by the Germans obey the Wade electron-counting rules and thus relate directly to both the polyboron cage compounds and the metal cluster, constituting a most significant development in my view.

N.N. Greenwood's (Leeds) plenary lecture was a stimulating review of recent metalloborane work, reporting a number of new species incorporating mercury, cadmium, zinc, or iron into borane frameworks. D.F. Gaines (Wisconsin) discussed the preparation and structure of a beryllaborane, $B_5H_{10}BeBH_4$ in which a $Be(BH_4)$ group substitutes for a BH unit in the B_6H_{10} framework. B. Stibr (Prague) reported some new monocarbon carboranes, azaboranes, and thiaboranes, and R.W. Rudolph (Michigan) described a series of new thiaboranes including some metal-thiaborane complexes. S. Hermanek (Prague) gave an important paper outlining an empirical correlation of ^{11}B nmr chemical shifts with certain structural features in borane frameworks. I presented two papers, both dealing with ONR-supported research. The first described recent work on metallocarboranes containing four cage carbon atoms, including the first x-ray studies of 14-vertex polyhedral cages, and the second reported the use of "triple resonance" spectroscopy (the first in boron chemistry) to study proton-proton spin couplings in metallocarboranes.

The IMEBORON meeting provided a highly useful exchange of information with other chemists in a variety of

disciplines, having in common only the involvement of boron compounds in some fashion. The rapid advances of German and some British chemists in the boron-cluster field, and the continuing emphasis on carboranes by the Russians and Czechs, show that these groups are clearly taking up the slack created by the sharp decline in the support of boron chemistry in the US. It appears from this conference that the pace of boron work in Europe is increasing in both the applied and the fundamental aspects. (R.N. Grimes, Univ. of Virginia, Charlottesville)

COMPUTER SCIENCE

EUROPEAN COMPUTER INDUSTRY

The Commission of the European Communities has recently published a report ["Community Policy for Data-Processing" COM(75) 467 final, Brussels, 10 Sept., 1975 (Commission of the European Communities, 2100 M Street NW, Suite 707, Washington, DC 20037 or 277 Park Avenue, New York, 10017)] proposing a set of well-defined objectives and development projects which are intended to maintain a viable computer industry in Europe.

In looking at the potential growth of the computer industry, the report postulates several trends which are relevant to the formulation of Community policy. The most significant trend identified by the report is "distributed processing": integrated systems of minicomputers and microcomputers. Related to this trend is a complementary bent towards federated systems of large computers made possible by advances in [digital data] packet-switched communications and low-cost minicomputers as network controllers. A related trend is the proliferation of low-cost and increasingly intelligent computer peripherals.

In order for the Community to be a leader in developing these trends and to achieve a "balanced partnership with partners in the United States and Japan," the report recommends that national governments should only continue financial aid "to promote promising associations between European producers." As a consequence of the virtual demise of UNI UNIDATA (a partnership between Siemens, Compagnie Internationale pour l'Informatique (CII) and Philips), the report seems to suggest a partnership of Siemens and International Computers Limited (ICL) since there are no other large mainframe manufacturers left, now that CII is (with the exception of its military and telecommunications divisions) being absorbed by Honeywell-Bull (HB). It is somewhat contradictory, however, that the Commission proposes subsidies of $6 billion to the computer industry at a time when France has taken a step to reduce its long-term industry support commitment by agreeing to the CII-HB merger.

Two additional areas which the Commission believes merit support are the peripheral- and integrated-circuits industries. In order to accomplish the former the report recommends that mainframe manufacturers buy each other's peripherals and set up joint production ventures such as NCR Computer Company and Control Data Corporation have done in the US. The Commission further recommends the building up of European Large Scale Integration (LSI) development facilities with special regard to the needs of the computer and telecommunications industries.

In addition to the general policy proposed by the Commission, the report lists a set of specific projects for approval by the Council of Ministers. It is proposed that the Long-Term Procedural Language-Europe (LTPL-E) Committee be supported in its efforts to develop a European standard language for real-time applications. Most widely used languages are CORAL 66 (Ministry of Defence Standard) in the UK, PEARL in Germany, PROCOL in France, and PL/1 in the US. RTL2 in the UK, LTR in France (Ministry of Defence Standard), and CMS-2/JOVIAL/TACPOOL in the US Department of Defense, are also used widely in selected areas for real-time applications. The report further suggests that unless a European standard is developed in the next two or three years, taking the best elements from existing languages but not based on any one of them, an international standard will be developed in the US and imposed on Europe to the detriment of European manufacturers. (The report does not seem to be concerned about the effect on the user community.)

LTPL-A (American Branch) has been less active in standardization efforts than its European counterpart, but the DOD Tri-Service Committee on Tactical Programming Languages has been actively developing a long-term successor to CMS-2, JOVIAL and TACPOOL. This Office has been involved in that effort by soliciting European computer-scientist participation in the requirements and design review process.

A second program proposed in the report includes development of portable machine-independent compilers (computer programming language translations) for FORTRAN and COBOL. The machine code generation phase of the compilers will be capable of providing object (machine useable) code for six of the most widely used computers. Related to this effort, the Commission proposes to develop a new systems language (European System Language), which would be used to rewrite the best available database management and transaction processing (information storage and retrieval) systems. Other projects include COBOL and FORTRAN conversion tools (to or from their dialects or other languages) and a machine-independent operating system for minicomputers.

The third program in the report proposes studies in data-security programming techniques, and data-base systems.

A fourth program includes a project to develop a generalized computer-software package for storage and retrieval of information. This package would satisfy information requirements for the legal, scientific, economic and environmental industries.

The fifth program in the report proposes support of research and development in packet-switched network technology. Specific projects include addition of an extra node (host/user facility) to the European Informatics Network at CERN (the European Nuclear Research Centre on the Franco-Swiss border) and experiments in packet-switched communications between CERN and the Rutherford High Energy Laboratory in the UK.

Although the goals proposed by the report represent no small undertaking by the European computer industry, the Commission believes they are achievable and therefore recommends a Council support commitment over the next five years (1976-1981) of $28 million. The go-ahead is to be given in late 1976 to the LTPL-E Committee to start a two-year real-time language development effort.

The greatest overall significance of the report is that it proposes a coordinated plan for the European computer industry. However, there exist serious doubts as to its achievability, given the current and projected economic conditions and the number of industry mergers and consolidations currently underway. (LCDR D.C. Rummler)

ELECTRONICS

ELECTRONICS AT ISRAEL'S WEIZMANN INSTITUTE OF SCIENCE

The Weizmann Institute of Science in Israel is a prestigious center for research and postgraduate education in the natural sciences. Founded in 1934 originally as the Daniel Sieff Research Institute for carrying out studies in technical bacteriology and in pharmaceutical and agricultural chemistry, it changed to its present name at the end of World War II, in honor of its first Director, Dr. Chaim Weizmann. Rapid expansion followed. Now it has more than 40 buildings occupying a beautiful campus in Rehovot which is about 15 miles south of Tel Aviv. The scientific complement of about 570 is supplemented by a technical staff of 515 and an administrative and service staff of 635. There are about 550 graduate students studying toward the MSc and PhD degrees.

The Institute consists of five Faculties, a Department of Science Teaching, a Graduate School, a Computing Center, an Experimental Animals Center, a Central Library and several other service units. The five Faculties are: Mathematics, Physics, Chemistry, Biophysics-Bio Biochemistry, and Biology. Each Faculty is further divided into two to eight Departments. Electronics is one of two Departments in the Physics Faculty, the other being Nuclear Physics. The Electronics Department has four Professors; two Associate Professors; seven Research Scientists, Fellows and Consultants; four Engineers and/or Chemists; and about 30 research students. Recently I visited Dr. E.H. Frei, Benjamin Abrams Professor of Electronics and Head of the Department; Dr. S. Shtrikman, Samuel Sebba Professor of Applied Physics; and several other faculty members. The

following is a summary of the research activities in the Electronics Department.

Five fields of activity can be identified, namely: magnetism, modern optics, quantum electronics and lasers, liquid crystals, and biomedical engineering. In the study of magnetism, the people at the Weizmann Institute have recently discovered fifteen new magnetoelectric materials. The existence of the magnetoelectric effect in the transition metal niobates and tantalates $A_2M_4O_9$ (A = Ta, Nb; M = Mn, Co) has been confirmed by the observation of electrically induced magnetic moments in these materials. Both parallel and perpendicular magneto-electric susceptibilities have been measured as a function of temperature in powder specimens. Other new magnetoelectric materials include $FeSb_2O_4$, Fe_2TeO_6, $MGeO_3$ (M = Mn, Co, Fe), $CrTiNdO_5$, $GdVO_4$, and antiferromagnetic monoclinic rare-earth oxide-hydroxides ROOH(R = Er, Tb, Dy). The magnetoelectric effect is employed as a tool for determining magnetic structures and measuring the strain dependence of exchange bonds in magnetic materials. On the subject of micromagnetism, attention is directed toward the development of models for two-dimensional domain walls in ferromagnetic films and the calculation of relaxation times of superparamagnetic particles with cubic anisotropy.

Research in modern optics includes holographic stereogram displays with very low aberration and distortion, novel recording materials (photoplastics and photodielectric polymers) for high-density storage and retrieval, and non-destructive testing and signal processing. Holographic non-destructive experiments to identify failure in airplane wings and to detect "de-bonds" in multi-layered material such as honeycomb structures have been conducted with cooperation of the Israel Aircraft Industries. Techniques are being examined for fabricating complex filters for the de-blurring of out-of-focus photographs with newly developed recording materials having a high efficiency and a large linear dynamic range.

In quantum electronics and lasers the main effort at the Department centers on the study of high-power flashlamp-pumped dye lasers that emit pulses in the microsecond regime and nitrogen-laser-pumped dye lasers emitting nanosecond pulses. In high-power short-pulse systems, shock waves are created in the dye solution, resulting in index inhomogeneities in the laser medium. The ultimate consequence is the termination of the laser action. Possibilities of the origin of these shock waves are investigated with a view to designing new configurations or overcoming this consequence.

The Electronics Department has developed efficient dye lasers with tuning capability over most of the visible spectrum. By using composite holographic gratings, each recorded with a different wavelength, simultaneous multiple-wavelength operation of a tunable dye laser with controllable output powers has been achieved. The Department has also developed a simple model for a nitrogen-laser-pumped pulsed dye laser for studying the effect of power coupling and medium gain on laser operation.

The use of high-power lasers in materials processing and drilling is another area of laser activity. For metals, the effects of drilling velocity and laser pulse-length on temperature distribution are being studied. The ambient temperature has a noticeable effect on the drilling of insulators. It was found that holes about 30% deeper can be drilled in sapphire with the same drilling parameters if the ambient temperature is changed from room temperature to 1000 K. The Department also has been successful in obtaining patterns of back-scattered light from cut gems that will identify the type and quality of the gems. The optical system is now being produced under license by Kulso, a Haifa-based company.

The work on liquid crystals is concerned with the role of symmetry and phase transitions in the physics of these poorly understood materials. Calculations of light propagation in distorted cholesterics are being made, as are measurements of the twist viscosity in several nematics.

Much activity and many accomplishments in biomedical engineering are in evidence, perhaps because Frei himself is a specialist in this area. One project involves the development of an instrument for measuring by ultrasound the extent of penetration of infiltrates in immunological skin tests. The instrument is now ready for clinical evaluation. In the field of ultrasound, the Department has conducted extensive experiments on safety of repeated and prolonged irradiations in fetal monitoring systems. Animals are subjected to irradiations at a frequency of 2.28 MHz

for five or 60 minutes, either singly or for five consecutive exposures at intensity levels of 164, 272, 490 and 1050 mW/cm^2. At an intensity of 1050 mW/cm^2, tissue damage was found to be identical with that due to overheating. At 490 mW/cm^2, no critical tissue temperature rise was observed, and macroscopic and microscopic examinations of the mothers, fetuses and neonates yielded no pathological findings. No congenital malformations were recorded and all of the exposed mothers were able to conceive again, producing healthy offspring.

A second project deals with ultrasonic stereoholography which is a 3-D imaging procedure of organs and biological specimens *in vitro* and will be especially useful for early detection and identification of breast tumors. An instrument for clinical use is being built for evaluation at the Guttman Institute and Cancer Clinic in New York. A third project studies the use of a previously developed cinedensitometric blood-flow measurement system to examine the physical properties of the arterial walls. The system has an accuracy of ±5%. The fruit of a fourth project is a device to keep liquids for intravascular infusion within the necessary temperature range under any environment. It is now being used by the Medical Corps of the Israel Defense Forces.

In yet another project funded by the Israel Defense Forces, the Department has developed a self-contained emergency heart-beat detector capable of determining whether any heart activity is present even under strong noise and vibration environments. A noteworthy past achievement is the development of a rechargeable implanted cardiac pacemaker which can be recharged every four months by a high-frequency transmitter in a non-traumatic way. Some work is continuing on developing an automatic analyzer for screening and testing patients with implanted pacemakers by general practioners or possibly even by para-medical personnel.

It is noted that much of the work in biomedical engineering is of a developmental, rather than research, nature. On the other hand, a theory without an instrument or a device in biomedical applications is not of much consequence. There is little doubt that Frei and his colleagues are doing frontier work and are so recognized internationally. The (triennial) XIIIth International Conference on Medical and Biological Engineering and the Vth International Conference on Medical Physics are to be held jointly in Israel in 1979. (D.K. Cheng)

ENGINEERING

SEVENTH INTERNATIONAL GAS BEARING SYMPOSIUM

The Seventh International Gas Bearing Symposium was held on 13-15 July 1976 at Churchill College, newest college of Cambridge University, and one of its largest (500 students). The College serves as living memorial to England's great statesman. Funds for its establishment were donated by persons and organizations all over the world, and Churchill lived to see its dedication in 1961. The emphasis placed in this College on engineering science is in accord with his wishes.

Dr. M. Wood, of the Cambridge Engineering Faculty, opened the meeting, stating that he had been selected to serve in order to provide continuity between the present Symposium and the preceding one two years earlier, for which he had served as concluding speaker! With deliberate intent to provoke discussion, Wood said that at the previous symposium gas-bearing technology had already evidenced maturity. Considerable understanding had been shown for the behavior of self-acting, externally-pressurized, grooved, and squeeze-film bearings. Also, much was known about methods of material selection, production, inspection and testing. True, the papers of the present Symposium represented modest gains in previously-explored directions, but what he really wanted to know, he said, is where are the new applications? Were gas bearings to be confined to currently known areas of application; *viz.*, gas circulators for atomic-power plants, dental drills, gyros, grinding spindles, computer tapes and flying heads, and lifting devices?

The validity of Wood's observations and questions was accepted in large part by the participants. However, some counter-argument was offered by O. Decker (Mech. Tech., Inc., Latham, NY). Although agreeing that gas bearing theory is a mature discipline and that the finding of new

application is very important, he contends that the gas bearing application field itself is not a mature technology. In other words, even with present applications the path to a finished consumer product is not smooth. Speaking from personal experience, Decker said that he frequently has convinced prospective customers of the operational advantages of gas bearings, only to lose out when machine modifications, delivery times, and price came into the picture. Ensuing discussion brought out a shift in emphasis during the past few years from retro-fit to integrated design, when gas bearings are to be used. In Decker's paper itself there is a summary of the principal installations since 1964 of motor-driven gas-bearing circulators, with specifications of type, location and design conditions.

The two and one-half day technical program was a well-balanced mix of theory, experiment and application. Porous bearings received considerable attention. R. McCrea and I. Donaldson (Queen's U., Belfast, UK) established criteria for the importance of fluid inertia within the porous matrix and slip at the matrix-lubricating film interface. In separate papers, B. Majundar (IIT, India) and D. Sun (Gen. Motors) explored the stiffness and damping properties of externally-pressurized porous journal bearings, with agreement concerning the effects of speed, porosity and supply pressure. R. Taylor and G. Lewis (Aston U., Birmingham, UK) compared theory with measurement for the dynamic performance of aerostatic porous thrust bearings. Numerical solution of the Darcy equation for the porous medium was accomplished using the "Roscoe" technique (ESN 28-9). As an application, H. Victor and J. Schmidt (Karlsruhe U., FRG) described an open-end spinning spindle driven by a Hall-commutated electric motor to speeds of 130,000 rpm.

Externally-pressurized (EP) bearings of several forms were described. N. Tully (Natal U., So. Africa) estimated the static performance and stability of a self-controlled restrictor thrust bearing designed for extreme stiffness. E. Blondeel, R. Snoeys and L. Devrieze (Catholic U., Leuven, Belgium), in an alternative design with the same objective, gave theory and experiment with stiffness induced by variable gap. E. Pink (Southampton U., UK) gave selected results from a very comprehensive experimental program determining the effect of various design parameters on the static performance of journal bearings pressurized with plain, or with recessed, feed holes. His results are in fair agreement with several widely used design methods, but his data suffice on their own to optimize this form of bearing. An experimental study was reported by A. and H. Mori (Kyoto U., Japan) on the effect of eccentricity upon the incidence of whirl in EP inherently-compensated journal bearings. Their results serve to remind us that half-frequency whirl is, strictly, a characteristic of self-acting, lightly-loaded journal bearings. In one of the most interesting papers, R. Haycock (Utah State U.) described his design of a gas-lubricated slide for translation of a movable mirror for a nitrogen-cooled interferometer. The bearing operates on cryogenic boil-off, and rectilinear motion is achieved to within 1/5 wavelength at 0.633 μm over a stretch of 4.7 cm! Low-frequency stiffness is obtained from servo-control of the gas supply pressure. The instrument is uniquely the product of one man. Haycock did all the theory and fabrication himself, even to the casting, when necessary, of his own alloy recipes.

Narrow-groove theory for spiral grooved thrust bearings of perfect geometry was presented by A. Huxley (ACO, Slough, UK). Having shown at the preceding symposium that geometric deviations explain most discrepancies between theory and experiment, Huxley now explored performance sensitivity to small departures from optimum design. H. Elrod (Columbia U.) showed that it is legitimate to use Muijdermann-type edge conditions with the usual narrow-groove differential equation, provided that the grooving has rectangular cross section. C. Pan (Shaker Res. Corp., Balliston Spa, NY) looked at the possible use of bands of grooving at the edges of a slider pad to diminish side leakage. He found that static performance actually deteriorates because of trailing edge leakage, and suggested a revised grooving pattern such that the grooving terminates near the peak of the film pressure.

One of the highlights of the symposium was the dual-paper presentation of D. Jones, D. Tate, and S. Holt (Leeds U., UK). The authors were concerned with detailed theoretical-

experimental comparisons for a marine inertia gyro of "H" configuration with twin-lobed rotor and inward-pumping spiral-grooved thrust plates. Holography was used to determine the thrust plate distortions due both to retaining-nut tightening torque and to operation. An infrared optical technique (Aga Theromovision System) was used to measure surface temperatures, along with a pattern of nineteen thermocouples. The results from experiment were compared with numerical computations involving simultaneous considerations of fluid film forces and thermal and mechanical distortions. Finite element programs yield the necessary temperature and stress fields. Good agreement was achieved. We can expect to hear more in the future from this investigation at Leeds, which represents the best of engineering tradition.

Some further papers in the applications area were as follows: R. Brodersen (Martin Marietta Aerospace, US) described a two-axis spherical gas bearing gyro intended for high performance fluidic inertial guidance. By proper selection of "stator" and rotor speeds, and of the inner and outer air gaps, drifts can be largely compensated. J. Huff and A. Rodgers (US Army Missile Command) gave a description of an EP elastomeric bearing gyro. The thin layer of elastomer (ethylene-propylene-terpolymer) bonded to the rotor inner surface absorbs launch loads up to 10,000 g, and then supports a hydrostatic gas film. A split sleeve aerodynamic bearing for light load applications was demonstrated at the Symposium by J. Hindle and G. Barnes (Lucas Aerospace Ltd., UK). These authors acheived stability in a self-acting cylindrical journal bearing by distorting a semi-rigid sleeve around the rotating shaft.

The perils in the procurement of inexpensive orifices for EP bearings were recited by J. Bennett and H. Marsh (Durham U., UK). For brass bushings with diameters ranging from 0.09 to 0.55 mm these men found not only variability in discharge coefficient from manufacturer to manufacturer, but from a single supplier. They also warned of considerable alteration when such orifices are interference-fitted on an EP bearing. Marsh also presented a paper showing how to design EP journal bearings for the minimum total of compressor and rotor-drive power.

The two Russian papers consisted of one on the use of lasers to measure dynamic rotor displacement by S. Penegin, Y. Tatachinkov and V. Koridanin (Institute of Mech. Eng., Moscow, USSR) and the other on the dynamics of EP Pneumatic Vibrator (title only) by E. Kibrikshtis, L. Baslite and V. Skaksuskas (Kaunus Polytech.). The former used modulation of a laser beam to measure displacements with total error less than ±1.2 μm at speeds up to 600,000 rpm. The latter gave a non-linear analysis, together with experiment, on an EP thrust bearing "gone wrong."

In the session on bearing materials and boundary lubrication B. Baxter (British Aircraft Company, UK) showed the existence of "high solid colloid" films on gas-bearing surfaces and considered their effect on friction. M. Stevens and S. Rudston (BPC, UK) showed that, individually, O_2 and moisture can reduce friction, but that together they can lead to inconsistent results which are presumably due to a larger than optimal formation of high friction oxide film. P. Gielesse (RIU, US) and P. Smith (ACO, UK) asserted that there is little point in evaluating comparative bearing performance until the mechanical properties of the material surfaces (degree and type of roughness due to fabrication) are fully characterized and optimized.

This writer concurs with Wood that the Symposium contributions represented significant, but modest, gains in the state-of-the-art. There was considerable unevenness in the theoretical work, with several papers tending to start back at "Square One." Few gas bearing investigating groups have been of sufficient size to provide the necessary continuity of analytical and computational effort, and much is lost as a result of personnel changes. A second obstacle to progress is the conservatism of industry--perhaps justified--but nevertheless hard to take. For example, to convince the textile industry of the feasibility of using cheap gas bearings on spinning bobs, National Engineering Laboratory, E. Kilbride, Scotland, set up a whole spinning machine for demonstration! Still no takers.

Attendance at the Symposium was off a bit from previous years--ninety persons in all. Forty-eight were from the UK, 8 from the US, 6 from West Germany and the Netherlands, and 4 each from France, Belgium and the

Soviet Union. Of four Eastern European offerings on the preliminary program, two were preprinted and one was presented.

The conference was very well run and the facilities excellent. The cost was high, $60/day including preprints, no doubt partially explaining the decreased participation. Proceedings will be available at a price of $36 from BHRA Fluid Engineering, Cranfield, Bedford MK430AJ, England. (H.G. Elrod, Jr., Columbia U.)

ENGINEERING RESEARCH IN SWITZERLAND

In Switzerland there are many contrasts that are, in large part, due to the influence of the countries that share a border with the Swiss: clockwise, beginning to the North, there is West Germany, Austria, Liechtenstein, Italy, and France. Variations are found in language, religion, and customs, and this article discusses programs of engineering research that differ in yet other ways: academic studies at the Institute of Technology in the world banking capital of Zürich, and industrial projects at the Battelle Center in Geneva, the classic ground for international diplomatic conferences and arbitration.

The Swiss Federal Institute of Technology, Zürich - Most educational institutions in Switzerland are administered, and largely funded, by the 22 Cantons (States) of the nation. The ETH (Eidgenössische Technische Hochschule) in Zürich, and its sister institution in Lausanne (Ecole Polytechnique Fédérale, EPF--note the change in language), are exceptions. They are entirely funded, in a most generous way (ESN 27-10:257), by the Swiss Federal government. The ETH administers educational programs in mathematics and in natural and engineering sciences to about 6300 students (80% of whom are Swiss). Beginning students are somewhat well-prepared, by US standards, and after four years they receive a *diplom*--the rough equivalent of a master's degree.

The Chairman of the Mechanical Engineering Department is Prof. Nikolous Rott who serves in the position once occupied by the pioneer aerodynamicist Jakob Ackeret. It seems that everyone likes Zürich, or something about it: James Joyce liked its wine, Goethe its scenery, and Wagner its attractive Madame Wesendonck. Rott is obviously a Zürich booster as well, having once studied at the ETH and, in 1968, having returned there from his professorship at UCLA. In accordance with the usual European practice, the university is subdivided into Institutes that are like research families, with a Professor very much the head of the household. As the Director of the "Institut für Aerodynamik," Rott is assisted by a staff of eight, two of whom are permanent staff members and the remainder are graduate students working for their doctorate in mechanical engineering.

The Department laboratories, and the work therein, are closely coupled to the needs of Swiss industry--many student projects are underway to examine the behavior and performance of valves, pumps, and other industrial hardware. The advancement of engineering science, in the form of more basic research, appears to be the responsibility of the institute directors, and is funded indirectly through the support of the institutes. Rott and his colleague Prof. H. Thomann are very much "into" the phenomenon of thermally-driven acoustic oscillations. Before discussing this work, however, we shall describe a few of the other projects that captured our interest.

For a number of years, Rott has engaged in an engineering hobby that has resulted in some remarkably educational demonstrations, as well as a good deal of enjoyment for himself and his engineering colleagues. The double pendulum is basically a main body suspended from a pivot fixed in space, and containing a second pivot from which a secondary body is hung. These are classical devices for the investigation of the coupling of the motion of the two bodies, which, for small disturbances, is linear. In general, the coupling is weak and the amplitude of oscillation of each pendulum is not largely influenced by that of the other. Under certain special conditions, however, the coupling is nonlinear and strong so that the ensuing motion is indeed wondrous to behold. Rott has analytically developed these principles and has designed several pendulums that prove the validity of his predictions. For those

who can't visit his office, and would like to build such devices, we recommend his paper, "A Multiple Pendulum for the Demonstration of Non-Linear Coupling," [*J. App. Math. and Physics (ZAMP)* 21, 4 (1970)].

The fluid mechanics laboratory at ETH is of historical significance as the site of the world's first continuous supersonic wind-tunnel, designed by Ackeret, and built in 1933 along with the spacious building that contains the M. E. Department. The tunnel is still operational although it has received little recent use because of a recession in interest in high speed flows. In the large low-speed tunnel, an investigation is underway to determine the behavior and effects of flow past two parallel rotating cylinders placed normal to the flow and spanning the tunnel from top to bottom. The space between the cylinders is the minimum that will permit rotation: The aim of the research (undertaken by Mr. Bridel, an assistant to Rott and a potential doctoral student) is to extend further Rott's many contributions to the understanding of moving-wall boundary layers. As the reader will surmise, a wide variety of stagnation and separation conditions are obtainable with the doubly-variable rotation of the two cylinders. The central effort at this time, however, is to devise and install a measuring system that will adequately record the magnitude and direction of the forces and moments acting on the rotating cylinders.

In the area of thermo-acoustics, a good deal has been going on at ETH since the late sixties. Rott's basic experiment, to which many embellishments have been added, consists of a low-temperature bath [(usually) liquid He] into which the open end of a half-open tube is inserted. With the closed end at room temperature, spontaneous thermally driven acoustic oscillations are observed. Rott's main interest has been in determining the conditions under which the oscillation will occur, and he has analytically and experimentally determined the viscosity-dominated branch of the stability curve.

In addition to the fundamental nature of such flows, and their amenability to analysis, they have been found to occur in cryogenic plumbing systems, sometimes with destructive effect. Rott and his coworkers are also looking towards an ability to obtain useful work from thermo-acoustic effects or, conversely, to develop a mechanical heat pump. In the latter instance, Thomann has long been interested in thermal gradients obtainable in mechanically driven resonance tubes. His latest document in this area stems from the 1973 dissertation by P. Merkli who is first author of the paper: "Thermoacoustic effects in a resonance tube," [*J. Fluid Mech.* 70, 1 (1975)]. The third paper in a series by Rott on "Thermally Driven Acoustic Oscillations," appears in *ZAMP* 26 (1975).

Battelle Research Center, Geneva - Battelle Memorial Institute is a non-profit organization which was established in 1925 in accordance with the (last) will of the Ohio industrialist Gordon Battelle. The influence of the Institute now reaches from Japan to California, the long way round, and is concentrated in nine research centers--in Frankfurt and Geneva with the remainder in the US. The Geneva Center is wholly funded from industrial and public interests in France, Italy, Spain, North Africa, Switzerland and, in conjunction with the Frankfort Center, the United Kingdom. Because of its international market, Battelle Geneva receives no defense-funded contracts, a situation that is currently under careful management scrutiny. The Center is essentially independent of its Columbus, Ohio headquarters (translation: if Geneva runs short of funds, Columbus provides little more than advice).

At Geneva the Center is divided into several departments, including economics, electrical and mechanical engineering, mathematics, and chemistry. The site is beautiful, and the organization appears to provide easy interaction among the some 600 staff (about half with university educations) and across a wide scope of soft and hard scientific interests. The Mechanical Engineering Department is the subject of these remarks, and here, according to J.P. Budliger who is the Head of the Thermal Engineering Group, some 55 individuals pursue projects in energy conversion, fluid dynamics, acoustics, maritime techniques, food engineering, and textile technology, to name a few.

Battelle Geneva gets involved in a research project because, typically, an industrialist with funds comes in and says, "I want to spend some money to get into the 'such-and-such' business." This was essentially

the origin of the work at the Center on a special combustor for a domestic heater with optimal exhaust products. Some control over the combustion temperature and the exhaust products is achieved by the recirculation of relatively cool flue gases. These are ducted in such a way that a strong swirl is created in the combustion chamber and Budliger is of the opinion that the aerodynamics of this flow and the resulting flame must be carefully controlled for optimum burner performance. This has been done in the burner developed at the Center which is now widely marketed in Europe. The work is continuing at Geneva to develop heaters of increased capacity.

Another project of interest, though currently only in the conceptual stage, is that of flapping-wing propulsion for ships. The basic appeal of such a device, which appears to be something of an unducted Hydropulser (ESN 29-2:61), is the opportunity to influence a large mass of water with a more direct motion than that characteristic of propeller-driven systems. Low frequency and high-amplitude motions can, according to the feasibility studies, deliver an overall propulsion efficiency equivalent to that now obtained by conventional systems. The study is currently concerned with ship/wing coupling, and although the presence of the ship does not appear to affect severely the performance of the flapping-wing, the reverse is by no means obvious. A multitude of questions remain regarding this scheme, and finding their answers will depend upon the identification of a sponsor for future work.

Because of the Center's sensitivity to the needs of industry, it is not surprising that much of the engineering research underway is manifested in new and innovative designs. In this area are such things as high-speed pedestrian conveyors, devices for painting underwater structures, and a novel helical screw machine designed for the concentration of oil slicks for subsequent removal. One of the most interesting design projects of the Center is to be seen in the attempt to determine the pathological and toxicological effects of smoking. Hundreds (perhaps thousands) of rats are caused to "smoke" by an ingeniously designed system that provides controlled dosages according to a programmed test routine. Judging by the yellow appearance of the once-white rats, the secret industrial sponsors of these tests may never be publicly identified--it's almost enough to make a person quit smoking.

The Geneva Center is directed by Dr. V. Stingelin who is an engineer-turned-manager with an apparent instinct for the physically possible and the economically profitable. Among the insights conveyed during our brief conversation was the observation that the analysis of unsteady motions, particularly in fluid dynamics, is an area of technological endeavor whose time has come. He feels that many discontinuous systems, such as the flapping-wing propulsor, have been rejected or overlooked in the past because of our inability to understand them and predict their behavior. With recent advances in computational techniques and hardware a new evaluation of these ideas may provide fertile areas for technological improvements.

At Battelle Geneva, one finds numerous graduates of the ETH and other Swiss educational institutions. The situation in Switzerland appears to be similar to that in the Netherlands (ESN 30-4:160) where many of the disadvantages of a limited economic base are offset by a close coupling between educational institutions and the users of their products--these products being students who have been equipped and motivated to pursue industrial goals. In a country the size of Switzerland, there is little cause for confusion between local and national interests. (R.H. Nunn and A.I. Barcilon)

CAVITATION RESEARCH AT THE TECHNISCHE HOCHSCHULE, DARMSTADT

The Technische Hochschule Darmstadt, founded in the year 1877, contains an important materials research institute with a double-headed arrangement--the Institut für Werkstoffkunde (IfW) and the Material Prüfungs Anstalt (MPA). Both structures operate with the same staff, equipment and building and until last year, both had the same director. However, now the IfW has Prof. Karl-Heinz Kloos as director and the MPA has Dr. Anton Bäumel. The IfW takes students and performs research for

various agencies. The MPA, on the other hand, is more applied and works for industrial clients. The tradition for objectivity of the MPA is such that the staff does no private consulting.

The research on cavitation damage is under the direction of Prof. Dr. Ing. Helmut Speckhardt who, along with Dipl. Chem. Rudolph K.E. Seyfarth, conducted a tour of the cavitation laboratory in particular and the entire materials laboratory in general.

The cavitation is produced by oscillating a solid surface in a direction normal to its plane at high frequency in a liquid. The drive is a magnetostrictive device having an electric winding which is energized at a frequency of 4.5-20 kHz and which provides the oscillating field for the magnetostrictive core-drive material. The amplitude of the oscillating surface is 25-80 μm with the larger amplitude at the lower frequency. Cavitation bubbles form at the oscillating surface in contact with the liquid and also drift through the liquid to a test surface that may be inserted under the oscillating bubble generator. The generating surface itself may be a test surface of a material specimen attached to the magnetostrictive drive mechanism.

A particular application of the cavitation research at Darmstadt is in the automotive industry. Since the engine coolant is fairly close to boiling temperature, cavitation is a problem in the water pump, engine block and other associated flow spaces. Among other things the effect of water hardness on cavitation damage is being studied. One unit of water hardness is taken to be 1 mg/l of calcium oxide, and damage due to 10-20 units of hardness to cast iron, aluminum alloys, copper and steels with various degrees of heat treatment is being studied. Also, the damage with distilled water alone is being assessed. Various mixtures of ethylene glycol and water (antifreezes), with and without organic chemical inhibitors of rust and cavitation damage, are being evaluated with respect to cavitation damage.

It was pointed out that corrosion can occur in connection with cavitation damage in a number of ways. If a protective coating is eaten away by cavitation, corrosion will proceed. Also, if there is plastic flow caused by cavitation, a slip line coming to a surface will expose unprotected metal and corrosion will proceed. Naturally, rust inhibitors would tend to slow down such processes. There is an attempt to separate mechanical and corrosion damage connected with cavitation by a choice of particular specimens for study. There is also an effort to measure the corrosion potentials and currents.

Other activities at the IfW-MPA include structural, glass, and grinding materials research and testing; chemical tests and lacquer testing; plastics research and testing; metals research and testing; surface technology and corrosion research and testing; physical testing and metallography; x-ray techniques and non-destructive research and testing. The writer also saw extensive long term fatigue and creep tests in progress.

In all, the IfW-MPA at the Technische Hochschule Darmstadt seems to be an impressive and practically motivated organization that engages in the full spectrum of activity from teaching to research, from short to long term projects and from fundamental to highly applied studies. Its services are much in demand by government agencies and industry, and for good reason. (M. Lessen)

SOME ASPECTS OF ELECTRICAL ENGINEERING EDUCATION AND RESEARCH AT THE TECHNION

The Technion--Israel Institute of Technology--was founded in 1924 originally as the Hebrew Technical College and acquired its present name in 1951. During its brief history it has developed into a respected institution for education and research in engineering and science. (A School of Medicine was added in 1971.) The Technion City Campus comprises some 50 buildings occupying 300 wooded acres on the heights of Mt. Carmel in the city of Haifa. At present there are about 6500 enrolled undergraduates, 2100 Master's and 400 Doctoral candidates. Technion's contribution to Israel's defense and economic development is reflected in the fact that it provides over 85% of the nation's engineers.

Admission to the Technion is based on a combination of the applicant's secondary-school grades and the results of Technion's own Qualifying (Entrance) Examinations in mathematics and physics. Graduates of Israel's

secondary schools normally serve in the armed forces for three years prior to beginning their higher education. Some outstanding secondary-school graduates who wish to major in science, engineering, or medicine are allowed an academic-reserve status if they pass a special set of examinations. In that case they can enter a university or the Technion first and serve two years in the military after graduation. About 20% of Technion's entering students belong to this category.

The Department of Electrical Engineering with 1200 undergraduate and 500 graduate (mostly part-time) students is by far the largest among about 20 Departments. Its faculty now comprises 11 Professors, 12 Associate Professors, 12 Senior Lecturers, six Lecturers and 35 Adjuncts. The present Chairman of the Department is Professor Raphael Sivan who obtained his PhD from the University of California (Berkeley) in automatic control and system theory in 1963. (Parenthetically it was personally gratifying for me to be told by Sivan that my 1959 book, *Analysis of Linear Systems*, had helped him when he prepared for his doctoral preliminary examination at Berkeley in 1961.)

For the BSc degree in Electrical Engineering a student must accumulate 165 or more credit-points, of which 119 are obligatory, 36 are on subjects chosen from at least three specialization groups, and the remaining ten are for free-choice subjects without regard to specialization. Depending on the type of course, each credit-point corresponds roughly to three hours of work weekly including class and expected homework time. The obligatory subjects consist not only of basic sciences (mathematics, physics and chemistry) but also departmental requirements on electromagnetic fields, linear systems, digital systems, electronic circuits and systems, energy conversion, computer programming, and a considerable amount of laboratory work. The Department offers 13 specialization groups of subjects. They are: networks, controls, communication theory, communication techniques, solid-state physics, electron devices, quantum electronics, waves and antennas, computers (a double group), power systems and drive, instrumentation, and nuclear science. Completion of a specialization group implies the election of three or more subjects from the group. In each of the two (7th and 8th) semesters of the last (4th) year, students in groups of two are required to do laboratory project work and hand in comprehensive reports. Judging from the assigned textbooks, I feel sure that the course contents are on a par with those found in better US engineering schools.

There are two options for satisfying the requirements of the MSc degree. A student can either take ten graduate courses (20 credit-points) and present a thesis on a research or engineering project, or take 14 graduate courses (28 credit-points) and present a final paper. Two of the courses must be in mathematics, and the student must defend his thesis or discuss his final paper before an examining committee. For the PhD degree, five courses (10 credit-points) beyond the MSc are required, the most important part being a dissertation based on original research. The Department of Electrical Engineering produces, on the average, about 40 MScs and 5 PhDs a year. In Israel, a Master's degree carries some weight in the engineering profession, whereas a Doctorate is generally not considered to be of equal practical value in terms of the years of working experience. Hence, only a relatively small percentage of MScs continue to work toward a Doctorate. For academic positions, a Doctor's degree is essential since it is a required qualification for appointments to the rank of Lecturer or higher.

My hosts at the Technion during a recent visit were Professor S. Raz (formerly Rosenbaum) and Dr. H. Cory, Senior Lecturer, of the Electromagnetic Waves and Electrophysics Group. Raz received his PhD degree from the Polytechnic Institute of Brooklyn in 1966 and has done work in the areas of stochastic wave phenomena, backscatter from moving targets, and numerical solution of electromagnetic problems. He is in charge of the Department's graduate programs. Cory obtained his PhD at the Technion in 1967 and worked for two years with the Groupe de Recherches Inosphériques at Saint Maur, France, before joining the Technion faculty in 1970. He has been working on the analysis of mode coupling in ion cyclotron whistlers and on the propagation of VLF electromagnetic waves inside and below the ionosphere.

It appears that conditions at the Technion do not quite encourage faculty members to do research. Several

reasons were mentioned. First, every full-time faculty member must teach one undergraduate and one graduate course each semester regardless of his research activity. Secondly, salaries are pegged with rank and seniority with almost no merit considerations. Thirdly, while external research support may augment a person's salary by 30%, it is much less strenous to teach a summer course for 20% and a much larger supplementary income can be had through consulting arrangements. Similar conditions also exist in many US universities, but most government-supported research grants in the US allow only a 2/9 (instead of 30%) summer supplement for faculty salaries.

I had a most interesting discussion with Dr. J. Shapira, an Adjunct at the Technion and, at the same time, the Head of an Electro-magnetics Group at the Armament Development Authority (ADA) of Israel's Ministry of Defense. Shapira has done some very good work on ray-analysis methods and conformal antenna arrays and was a co-winner of the IEEE Antennas and Propagation Society's Best Paper Award for 1975. His group at ADA has 70 people which includes 40 scientists and engineers. There is a strong coupling between ADA and the Technion in personnel as well as in research work. For instance, Raz is a consultant for ADA, and a number of ADA's engineers are working for advanced degrees at the Technion.

One of the ADA-Technion research projects is the analysis and synthesis of frequency-selective surfaces. Perforated metal sheets of finite thickness (1 mm) with apertures of simple geometries (circles, rectangles, orthogonal slots, etc.) are considered, and analytical tools have been developed for radome design. Radomes with a 1/2 dB attenuation have been made for x- and Ku-band operation with a bandwidth of 10 to 20%. The characteristics of various special antennas and arrays are studied in order to improve their design. These include traveling-wave, log-periodic, wire-grid, and monopulse antennas; conformal, adaptive, and Yagi-Uda arrays; and the feed and beam-forming networks. For countermeasure applications the shape and material of cylindrical dielectric rods that will provide a maximum absorption of electromagnetic energy are explored. Reactive loading is one approach, but its high-Q property is not desirable.

Attention is also directed toward the electromagnetic shielding problem especially under transient conditions and when apertures exist in the shield. This is a problem in which I have a personal interest. The ADA-Technion people are undertaking an SEM (singularity-expansion method) study of multiple dipoles and, at the same time, using Prony's method to extract the frequency-domain singularities from the time response. There is now no general theory which can predict the loci of the singularities of structures other than the simplest geometrical shapes. In order to make accurate antenna measurements under all conditions, the ADA has invested more than $2 million in the construction of a microwave anechoic chamber and in equipping an antenna range.

Before concluding, I wish to mention the formation, earlier this year, of an interdisciplinary Solid-State Institute at the Technion. It used to be a unit within the Department of Physics, but now draws the talents also from the Departments of Electrical Engineering and Materials Engineering. At present the Institute has about 20 professional people and its Director, Professor K. Weiser, reports directly to the Vice President for Research. Weiser himself is an expert on amorphous and liquid semiconductors. He had worked for 16 years at the IBM Yorktown Heights Laboratory (NY) before joining the Technion four years ago. I spent over an hour with him during my visit. He indicated that, among other things, the Institute is currently active in the study of narrow-bandgap materials (InSb, PbSnTe), amorphous semiconductors (Se, Si, As_2Se_3), ion implantation, and GaP LEDs (light-emitting diodes).

It is known that narrow-gap semiconductors can be made either n- or p-type by the implantation of various ions, but the mechanism of the electrical activity is not always clear. This is being examined by using Rutherford back-scattering techniques. Amorphous semiconductors are studied because of their actual (e.g., Xerography) and potential device applications. The mechanism by which photo-excited carriers produced in thin amorphous-semiconductor films absorb infrared light, and the recombination process of such carriers, is being

looked into. Regarding ion implantation, the investigation centers on the study, by the Raman scattering technique, of the recrystallization mechanism of amorphised layers and the profile of damage created by ion bombardment. The research on GaP LEDs examines the non-radiative decay channels by selectively exciting a given isoelectronic trap and observing its photoluminescence lifetime as a function of crystal temperature and intensity of excitation. The Institute people also are working in the fields of solar cells, surface physics, and isotope separation by lasers. The USAF is supporting a project on deuterium-isotope separation from molecules which contain oxygen by the use of focused radiation from an intense pulsed CO_2 laser. (D.K. Cheng)

ICHMT SEMINAR ON TURBULENT BUOYANT CONVECTION

The International Centre for Heat and Mass Transfer (ICHMT) was founded in 1968 by a group of distinguished scientists whose goals were to promote international cooperation and to support developing countries in their endeavors to apply the most recent developments in heat and mass transfer. The ICHMT, with headquarters in Belgrade, is now backed by 24 national member organizations and is the sponsoring agency for a continuing series of international seminars and workshops. In addition, a quarterly journal (*Previews of Heat and Mass Transfer*), a bimonthly letters journal (*Letters in Heat and Mass Transfer*), a newsletter, several books, and the proceedings of annual seminars are published under the auspices of the ICHMT. The Centre interacts with UNESCO, and a recent product of their mutual efforts has been the establishment of regional centers in South America and in southern Asia.

The seminar series began in 1968 with consideration of turbulent boundary layers, and the menu of subsequent topics reads like a recent history of "where it's at" in heat and mass transfer--separated regions, rheological fluids, liquid metals, heat exchangers, flames, vegetation (environment), energy production, and, in the 1976 seminar, (30 Aug - 4 Sept) turbulent buoyant convection. The site of the meeting was Dubrovnik, Yugoslavia, an international crossroads whose natural beauty appears to have led to its acceptance as the continuing site for ICHMT seminars.

The attendance was largely composed of delegates from the industrialized countries, which led me to speculate as to the role of such meetings in "supporting developing countries." With this exception, however, the attendance was unusually well balanced, with approximately equal representation from the US and the USSR. Political ties between the USSR and Yugoslavia appeared to have resolved some of the difficulties that so often lead to Russian representation "in name only" at international symposia. Even so, the USSR delegation seemed to consist largely of "big names," with the technical proletariat left at home to share a stern travel policy. The program, containing 55 papers and 10 invited lectures, was divided among 13 countries in rough proportion to their level of national activity in heat and mass transfer. The total attendance of some 112 was likewise proportionately distributed so that the interactions between delegates took on a naturally international flavor. Ten sessions were scheduled with their ingredients falling generally into the categories of turbulence/buoyancy interactions, buoyant plumes, stratified flows, internal and external flows with natural convection, air and smoke movement in fires, flames and flows with heat addition and combustion, and multi-phase buoyant flows.

The welcoming address was delivered by Prof. N. Afgan of the Boris Kidrich Institute (Belgrade) and Scientific Secretary of ICHMT. Professor D. B. Spalding (Imperial College, London) was introduced as the Chairman of the Seminar Committee, but it became clear as the Seminar proceeded that his involvement far exceeded this administrative function. For about 10 years Spalding and his students and coworkers in the Department of Mechanical Engineering at IC have contributed to the collection of newly-solved problems in fluid mechanics and heat transfer (see ONRL Report R-2-73 by D.F. Dyer) at a rate that has almost bewildered the international engineering community. Not surprisingly, a segment of this community views Spalding's success as a matter

of over-exploitation of computer capabilities, with insufficient regard for the advancement of fundamental understanding. Though unwilling to comment on this issue, I can report that a large number of the papers presented drew heavily upon the results of Spalding's efforts, and his presence at the Seminar was a stimulating influence.

The opening invited lecture was presented by J S. Stuhmiller (Jaycor, Del Mar, Calif.) whose discussion of the theoretical considerations of turbulent buoyant flows proved to be one of the highlights of the Seminar. Stuhmiller reviewed those aspects of buoyancy that are likely to influence the behavior of turbulent flows. He pointed out that any disturbance to a buoyant fluid will cause internal waves to be generated and radiated. Turbulence, therefore, can lead to a dispersive redistribution process in a buoyant flow that is an essentially new phenomena in fluid behavior. Stuhmiller also pointed to several other unique aspects of buoyant turbulent flow, including a natural tendency towards anisotropy and the influence of buoyancy in driving turbulence towards a two-dimensional state. To complete his remarks, Stuhmiller described several laboratory and numerical experiments that are needed to shed light on these special effects. His paper provided a difficult act to follow and, as noted by Spalding, who chaired the session, his observations may lead to doubt about the validity of current turbulence models when used in the analysis of buoyant flows. It was rather interesting to observe the subsequent parade of numerical works based upon ice made substantially thinner by Stuhmiller's insights.

Without intending a pun, A. Zukauskas (Academy of Sciences, Lithuanian SSR) stated that "recent advances in the solution of motion-and-energy equations, which are also applicable to turbulent mixing in cooling lakes, present a deeper approach to the problem." His invited lecture was rather descriptive but did serve to emphasize the concern in the USSR for adequate sources of cooling water for powerplant processes. Since modern nuclear powerplants are limited to efficiencies of about 33%, the predicted future generating capacities on the order of 6000 MW will lead to required cooling rates of twice that amount. Zukauskas' main concern was the incorporation of meteorological effects in the modeling of the total heat balances of cooling lakes, and his paper provides a useful description of the Soviet efforts in modeling the heat and momentum transport processes occuring at the air/water interface.

The main thrust of the Seminar was in the direction of numerical modeling, and a welcome respite from such matters was provided by P.G. Seeger, Director of the Fire Research, U. Karlsruhe. Seeger rather amazed the audience with two aspects of his presentation: (1) the air and smoke movements in burning buildings can be predicted by the simplest of considerations, such as Dalton's law, and (2) when a new fire safety design is proposed for public buildings the German approach (which, I later learned, is not uncommon elsewhere) is to set fire to an actual building that incorporates the design. The first of these revelations led to mixed feelings among the mathematically high-powered audience: skepticism and humility. The discussions in the public rooms naturally drifted toward the relative costs and credibilities of burning buildings and of numerical models.

A notable frustration was provided by the famous Soviet Academician, S.S. Kutateladze (now at the Siberian Division of the USSR Academy of Sciences) who departed from his prepared text, titled "The Model of Turbulent Free Convection Near a Vertical Heat Transfer Surface." Kutateladze read his remarks in Russian and the audience, without a script for guidance, had difficulty following the translation. The frustration came in when it became clear that Kutateladze was describing his latest turbulence modeling efforts in which he (apparently) has theoretically derived the value of 0.4 for the Kármán constant. There was widespread hope among the delegates that this potentially important result will soon be described in the open literature.

Spalding's contribution to the series of invited lectures came in the form of a paper titled "Free Convection Phenomena in Gas-Liquid Mixtures." His well-organized and dynamic presentation proceeded logically from a description of the practical importance of the topic (boilers, chemical and nuclear reactors, electrolysis, breaking ocean waves, etc.), through a listing of present

difficulties (interphase transport, coalescence and disruption of phases, wall effects), to a description of various proposed solution methods. With what might well be called the "Spalding Numerical Can-Do Attitude," he spoke of multi-phase problems as numerically simple extensions of single-phase issues, with the necessary additional information contained in the multiple equations of mass continuity. His optimism stimulated an interesting response from the session chairman, Academician M.A. Styrikovich (Institute of High Temperatures, Moscow), who cited 50 years of experience (and little else) as evidence that the problem was too complex for numerical solution.

As is always the case in these pages, insufficient space exists to provide a complete compilation and review of the meeting contents. Here I have described only a few of the more memorable invited lectures and have left unmentioned the contributed papers, many of which were noteworthy. These included the description of bursting phenomena in the turbulent boundary layer on a heated flat plate, in which buoyancy effects lead to decreased transport resistance (N. Kasagi and M. Hirata, U. Tokyo); the theoretical demonstration of the influence of buoyancy in damping turbulence in a horizontal surface jet while increasing it in a vertical jet (M.S. Hossain and W. Rodi, U. Karlsruhe); the use of an inviscid model to show the interaction of buoyancy and turbulent diffusion to form internal waves (O.F. Vasiliev, *et al.*, Siberian Division, USSR Academy of Sciences); the resurrection of the line impulse model and its application with remarkable success to jets in crossflows (V.H. Chu, McGill U., Montreal); the presentation of a general method for high order difference schemes (B.M. Berkovsky and V.K. Polevikov, Liukov Heat and Mass Transfer Institute, Minsk, USSR); and a carefully controlled comparison of central and upwind differencing techniques in which it was shown that the two methods can lead to drastically contradictory solutions under identical convergence criteria (J.J. Portier, U. Liège, Belgium, and O.A. Arnas, LSU). The Proceedings are available from Hemisphere Publishing Corp., 1025 Vermont Ave. NW, Washington, DC 20005.

The Seminar again revealed the shaky state of turbulence modeling, with or without buoyancy. In the use of so-called "sophisticated" models, where rate equations are used in place of the old-fashioned algebraic relationships, it is not uncommon to employ 10 empirical constants whose values are based less on measurement than on a favorable final outcome. By the time these constants are dumped into a digital electronic bag, along with multiple coupled non-linear partial differential equations and their complex boundary conditions, and shaken sometimes for hours, it is miraculous indeed that something more than fried chicken comes out. Clearly, more work is needed, and perhaps some fresh starts. In the conference itself, there was a lack of problems involving complex geometries and a deficiency, in spite of the advertised program, in the treatment of problems involving multiple phases and species.

I've reserved a paragraph here to get in a few words on a problem that continues to plague technical conferences, especially international ones. From the final program of the 1976 Annual Seminar, there were 13 absentees (about 20% of the program)--10 authors, 2 session chairmen, and 1 invited lecturer! This, unfortunately, is not exceptional although, in this case, the US did worse than usual--the missing session chairmen, invited lecturer, and six of the authors were American! It seems to me that this is not an area in which the US need compete with the USSR, and that it is past time for conference organizers to deal harshly with all but the most justifiable cases. Perhaps those whose excuses are not sufficiently convincing should be listed in the proceedings--not as contributors but as no-shows. When invitations are issued and accepted, and final programs printed, a considerable professional commitment is invested by the conference organizers. A lack of reciprocal commitment from the participants is offensive to all concerned.

Despite these lamentable difficulties, and the length of the meeting--five solid days of buoyancy is not exactly uplifting--the ICHMT has undoubtedly produced another landmark event in the international annals of heat and mass transfer. (R.H. Nunn)

ENVIRONMENTAL SCIENCES

APPLIED CHEMISTRY AND POLLUTION IN FRANCE: AN IRCHA CHAT

IRCHA, the Institut National de Recherche Chimique Appliquée, is a public establishment, industrial and commercial in character. Essentially a center of contract research subject to professional privacy, it does for the public and private sectors basic and applied studies in chemistry and pollution. It assists and advises industries which wish to profit from a specialized research laboratory without becoming permanently committed to its financial support. Having discussed with the client the problems that prompted the incoming request, IRCHA provides services and materials, and establishes all necessary contacts for laying down the orientation of the research and for examining the results.

The style of organization which justifies the word "public" is of interest since it distinguishes IRCHA from many non-profit laboratories linked to industry in the United States. The typically French--or European--combination of public and private functions has been noted in ESN in the case of the Laboratoire Central des Industries Electriques (ESN 29-7:323, 1975--Potter & Schulman). The head offices of IRCHA, comprising directorates for research and for finance and adminstration, are in Paris. Ministerial control is exercised on the one hand by the Ministry of Industry and Research which provides about half of the contract work of the laboratories, and on the other hand by the Ministry of Economics and Finance acting through the State Comptroller. The main research laboratories are at Vert le Petit near Brétigny sur Orge, in an area notable for its technical installations. These laboratories also control a regional laboratory at Lille, an experiment station at nearby Corbéil, and an air pollution standardization office at Strasbourg.

The laboratories are organized along lines of competence in chemistry, water pollution and air pollution, and each department has special contacts of its own in the Ministries and elsewhere. These include the Délégation Générale à la Recherche Scientifique et Technique (DGRST) which, under the Ministry of Industry and Trade, formulates French research policy for the appropriate interministerial committee (CIRST). Another example is the Centre National d'Etudes Spatiales (CNES). A third is the Bureau National de la Métrologie for which IRCHA functions as an evaluation center for instruments used in assessing water pollution.

Assessment and Prediction of Urban Pollution: My visit to IRCHA was the result of interest in some of the work of the head of the air pollution laboratories, Dr. Michel Bénarie, so that most of the limited time available was spent with him and his deputy Dr. J. Guichard. Since the scope of Institute activities is amply illustrated in attractive brochures, I shall refer only to a few of the items that came to my attention.

In recent years Bénarie has been concerned with the principles of data collection and interpretation, especially with the spread of pollutants through the atmosphere. In 1972 he summarized the results of a survey of sampling networks in some urban areas in several countries. He has since functioned as something of a gadfly, bothering the advocates of overblown projects in which the errors lurking in faulty data are cumulatively magnified by computer processing so as to result in the emission of impressive outputs pointing irresistibly to invalid conclusions. While perfectly prepared and equipped to use elaborate methods of computation when the input warrants it, Bénarie prefers simplified approaches in which a certain postulational crudity is matched by imperfect meteorological data and failure to attain satisfactory local assessment of pollution levels. In reports of work done for the US Environmental Pollution Agency (EPA) he points to flaws in the notion that the atmosphere is uniform even over short distances or brief periods of time. He criticizes the application to the atmosphere of statistical averaging techniques valid only for stationary processes; carried to extremes, they would predict uniformly grey cloudless skies.

As an alternative approach he has found empirically that frequency distributions for wind velocity, v, and for the concentration of oxides of nitrogen around a point source, c, are both quasi log-normal (I say "quasi" because a Rayleigh, or bivariate normal, distribution is thought

by meteorologists to be more likely). This means that if one knows the wind velocity frequency function at a given place, one can predict the probability that a certain pollutant concentration will be exceeded when the component of wind velocity in the direction source-to-detector falls below a certain value. Construction of a radial wind frequency chart about the point source is helpful in making such predictions. Bénarie claims only that this is a useful beginning; he uses experimental data to show that the relationships are less simple for a thermal pollutant such as sulfur dioxide and admits that the presence of a "sink" caused by photochemical action would further complicate matters. In the case of pollution from an urban area, equally simple calculations based upon a "box" traversed by wind have led to values for annual mean pollutant concentrations and to a simple rule for prediction of dangerous "episodes." In both cases agreement with measured values has been as good as that obtained using more complicated predictors.

Among items essential to evaluation of air pollution Bénarie has examined two others. The first has to do with standardization of air samplers. He asks whether discrepancies between results obtained with two samplers should be attributed to differences between samplers or to differences in the air sampled. Conventional belief has it that increasing the volume of air sampled causes the variance between samples to approach zero. Obviously this cannot be so if two distinct large volumes of air are to be sampled, for this would necessitate placing the samplers far apart; the farther apart, the greater the probability of gross differences of composition. But what if the samplers are kept close together and sample volume increased by prolonging the sampling time? Experiments by Courtecuisse and Bénarie showed that even when the sample volume is as great as 200 m^3 spread over 24 hours the deposits analyzed for 11 metallic elements on four quadrants of a single filter still showed a standard deviation of about 10%. Bénarie therefore doubts whether samplers can be reliably compared by this means.

The second matter scrutinized is that of permissible limits of exposure of populations to pollutants. At present such limits are set more or less arbitrarily, often for the good reason that statistical information is unavailable. Bénarie considers how the idea of the dose-frequency diagram, generally accepted by toxicologists, can be applied here. Ideally, the effect of a pollutant could be presented in a three-dimensional plot of frequency function against log concentration (c) and log exposure time (t) or as a set of diagrams on the log c - log t plane. Existing data are too scanty for this to be done properly, but for illustration Bénarie has used published estimates of excess deaths and of respiratory illness attributable to sulfur dioxide. These led to a few isolated points on the planes of constant frequency. It is seen that exposure to 0.5 mg/m^3 SO_2 for two days results in 2% excess deaths, and for one year in 10% respiratory illness. At 0.1 mg/m^3 the excess deaths are presumably much fewer (no data) while respiratory illness has fallen to 2%. Clearly even this limited type of information, if trustworthy, would provide a basis for selecting a permissible level for SO_2. The next and more difficult step is to organize data collecting so that frequencies relative to the whole population can be recorded.

Basic and Biomedical Aerosol Research at IRCHA: Responsibility for basic aerosol research rests largely with Guichard. A laboratory tour showed much of interest in connection with (1) characterization of natural and industrial aerosols, (2) the preparation and manipulation of aerosols for medical research, and (3) cleaning of polluted air. The suspended matter in air is being measured by β-ray absorption and--under contract with EPA--by mechanical impact sensing. Most of the work on impact sensing is devoted to means of creating a particle beam *in vacuo* and avoiding differences of sensor response due to physical peculiarities of the particles; the sensor was a lamella of thin vinyl foil. A trick that may later prove useful in enhancing sensitivity is to arrange for the particles to impinge on the sensor at its resonance frequency. The electrical properties of aerosols are also getting attention. Guichard has prepared a fine pencil of aerosol particles in laminar flow and, passing this through a condenser field, has obtained spectra well resolved with respect to electronic charge. He is also studying charge transfer from aerosols to

solid surfaces, which occurs in chimney stacks. Finally, an Army project deals with the pathogenicity of airborne microorganisms.

In category (2) some work is planned under a government program on the pulmonary retention of particles or droplets such as asbestos (a common atmospheric pollutant during demolition operations), sulfuric acid and sodium chloride. New generators of monodisperse aerosols have found other biomedical applications: mists of acetylcholine (ACh) solution are used in studies of the effect of ACh on respiratory parameters; tantalum aerosols can be used in lung radiology, and mass vaccination by aerosol inhalation is being considered at Lyon.

The generator of tantalum (and other) aerosols is called the "Puldoulit." A bed of glass beads (100-200 µm) mixed with a small fraction of tantalum powder of much smaller particle size becomes fluidized and "boils" when air is passed through it at a sufficiently high rate. As a result of various mechanical events occurring as the air bubbles burst, single tantalum particles are expelled at velocities exceeding that of free fall and an aerosol is generated. The clinical use of such aerosols in radiology is being considered by the radiologist Professor P. Bernadac of the Hôpitaux Maringer, Fournier et Villemin at Nancy. When I visited him, Bernadac showed me a simplified "Puldoulit" that he had been examining in preparation for possible visualization of the lungs when other procedures are excluded by the state of the patient. Tantalum has the advantage of becoming evenly distributed in the lung when inhaled and of producing no mucous reaction. However, the aerosol is explosive. Further, particle size is critical since particles in the 5 - 10 µm range are completely eliminated while below about 3 µm they are partially retained and may give rise to a fibrotic syndrome. Bernadac feels that the apparatus must be modified to produce more uniform dispersal and that a much narrower size distribution will have to be attained in the starting material furnished by commercial sources. I did not pursue the matter on being told that much clinical experience with tantalum inhalation has been gained in the US.

The cleaning of polluted air, our third topic, has several aspects: removal of industrial contaminants and odors by scrubbing, elimination of airborne infection in intensive care and other hospital facilities, and design of dust-free rooms for use in preparation and assembly of solid-state components and in other sensitive procedures. All these are important elements in the work of the air-pollution laboratories at IRCHA.

Etics and Emics, Phonetes and Olphemes: It may seem a far cry from chemical scrubber deodorizers to speculation on the information content of olfactory messages, but the research atmosphere at IRCHA is by no means inimical to such flights. Bénarie confronts the well-known fact that both the instinctual and the learned responses to odor are far more complex than might be supposed from interaction of a chemical structure and a receptor site. He seeks therefore to apply to odor messages principles already developed in linguistics: he traces analogies with phonetics, representing the objective category of language, and phonemics, standing for the *Gestalt* aspect--the ability, if you will, to recognize a pattern which is something more than the sum of its parts--which cannot be derived from phonetics. Similarly, various objective mechanisms of olfaction, such as different chemical structures, may convey the same message through a common but unidentified *Gestalt*. The problem of odor, like that of language, is to identify the units of olfactory information or "olphemes" and to understand the principles by which olfactory messages can be constructed from them. "Research towards a basic understanding of the sense of smell," Bénarie says, "is comparable to the deciphering of an ancient text." The initial step of identifying the olphemes, though in his view experimentally feasible, has not yet been taken.
(J.B. Bateman)

GENERAL

INTERDISCIPLINARITY, PHOTONS, AND CHEMISTRY

During the past decade and a half "interdisciplinary" has become a word to conjure with on the scientific stage. I use the word "conjure" advisedly, for my observations of some so-called interdisciplinary enterprises indicate that their predicted benefits may be rather illusory. (See also "Tribology--Technology or Tautology," by R.H. Nunn and H. Herman, ESN 30-9:408) A very thoughtful analysis of interdisciplinary approaches in science was given in these pages by Martin Blank (ESN 29-9:397) and in his ONRL Report R-12-75. The following admittedly less profound reflections on interdisciplinarity were stimulated by my attendance at a meeting entitled "Interdisciplinary Aspects of Photochemistry" organized by Dr. J.J. Bonet-Sugrañes, Instituto Químico de Sarriá, held in Barcelona in early August. It may be useful to begin by giving my perception of how interdisciplinarity emerged so prominently on the current scientific scene.

When science was known as Natural Philosophy, the universe was viewed as an integrated whole through which one could wander at will without tripping over mental boundaries. And the proverbial Renaissance Man reputedly felt equally at home speculating about the nature of things, painting a picture or composing a sonnet or a song. In the modern era, technological industries and garage-mechanic inventors were in the habit of using an interdisciplinary approach to problem-solving long before this approach was identified and labeled as such. This condition, however, was not generally true in academia, where knowledge had become increasingly compartmentalized into separate disciplines taught in separate courses by separate Faculties. In the late 1950s/early 1960s a group of American scientific leaders who had not lost sight of the essential unity of science coupled their vision with the pragmatism of a few industrial research managers and the political know-how of key Government science administrators in a campaign to break down some of the academic barriers in the physical sciences; their action consisted in identifying an interdisciplinary field called "Materials Science." Most of the university fraternity ultimately went along with this--in part, at least, because of the financially persuasive argument that Congress was more likely to support an erudite field like solid-state physics, for example, if it was merged with more earthy activities like metallurgy and ceramics under the understandable lay term "materials." As a consequence, a dozen or so "Interdisciplinary Materials Laboratories" were established at several leading universities in the early 1960s, largely under DOD (ARPA) auspices. (The administrative responsibility for these was transferred to the National Science Foundation a few years ago.) By this means a movement toward "interdisciplinarity" in US academic circles was fostered, and since that time the term and concept have been increasingly invoked in discussions of scientific education and research, not only in the materials field but in other areas as well.

Now, if there is any field that is interdisciplinary almost by its very nature, it is one that contains "photo" as a prefix in its name; photography, for example, involves the disciplines of physics, optics, inorganic and organic chemistry, and even extends beyond science into art. My expectations, therefore, were that the Barcelona conference would distinguish itself as a superb example of interdisciplinary interaction, underscoring the widespread importance of photochemistry. Alas! this proved not to be the case. The first speaker, Dr. Günther O. Schenck (Institut für Strahlenchemie, Max-Planck-Institut für Kohlenforschung Mülheim-Ruhr), did all that a keynote speaker should do, opening his talk with a survey of the truly remarkable scope and interdisciplinarity of photochemistry: photography and all its offshoots; photopolymerization; photosynthesis; vision; environmental effects (smog formation, photoeffects in the upper atmosphere); photodegradation of materials; photocatalysis; photochemotherapy; and "photophysical" phenomena such as luminescence and the use of photoexcitation in isotope separation. Although this talk paved the way for excursions into the many fields that border photochemistry, only a few of the other talks--by T. Matsuura,

(Kyoto University) on organic photochemical approaches to photobiology; R. Srinivasan (IBM Yorktown) on organic photochemistry and semiconductor technology; M. Archer, (Royal Institution, London) on photogalvanic cells; H. Tronnier (Dortmund) on phototherapy in dermatology--followed Schenck's inviting lead, and most of the 30 or so invited and contributed papers might as well have been given at a specialists' symposium on photochemistry.

Sadder still, photochemistry was tacitly assumed to be composed almost exclusively of reactions in organic systems, and even within this restricted domain it was confined to reactions provoked by photons roughly in the 1-5 eV range. The photochemistry of inorganic materials was not mentioned; neither was there any discussion of the new spectral regions being made available by synchrotron radiation nor of the photochemistry that has been made possible by intense sources of infrared laser light.

In response to a question on the symposium's theme by its organizer, Bonet, as to how academic institutions in Spain could best foster interdisciplinary activity, there was a rather awkward silence from the contingent of North American (US and Canadian) academics, leaving it to other participants to suggest answers. The failure of the vast majority of the leading photochemists in attendance to rise to the challenge of the conference's title was, of course, a disappointment, particularly since the organizing committee had done such an outstanding job in affording the photochemistry community an opportunity to explore all the implications of the subject to the fullest.

However, the above necessarily negative-sounding sketch of the meeting by no means conveys its value for the writer (and perhaps for other participants) in stimulating a closer consideration of the current popularity of interdisciplinary activities. Looking back at the meeting, two significant points emerge.

First, interdisciplinarity, which is both an attitude and a methodology, is laudable and valuable in both contexts; but one must recognize that it is not the only useful attitude nor the only effective methodology. Interdisciplinarity is not everyone's cup of tea. Enormous contributions have been and will continue to be made to science and technology by researchers--like the majority of those at the Barcelona meeting--who are better suited to deal with focused, discipline-oriented problems; it should not be forgotten that they are the ones who accumulate vast bodies of detailed information and stretch concepts to the limit, providing the great interdisciplinarians and synthesizers with the basis and the inspiration to make major advances. I should emphasize very strongly that this observation is neither a call for the re-Balkanization and compartmentalization of science nor a plea for infinite patience with researches that concentrate more and more on minutiae within a narrow field. It is a reminder that science owes much to the discipline-oriented specialist, and that he should not be forced into the ill-fitting costume of the interdisciplinary generalist because it happens to be the fashion of the day.

Secondly, true interdisciplinarity, so vitally important for the progress of science and its influence in society, should not be debased by casual employment of the word or by exploitation of the label for secondary purposes. Some activities are interdisciplinary by their very nature because they address real-world problems in systems which are generally complex; clearly medical science is one of these. There are also legitimate "synthetic" interdisciplinary fields, where in order to solve problems one must recombine specialities that once were very wisely separated and pursued as independent narrow disciplines. Most engineering fields are interdisciplinary in this sense. There are others of this type. Thus, interdisciplinary "Ocean Science" and "Space Science" have an honest ring to them, in my opinion, and "Materials Science" just about squeaks by. But an "Energy Science" (which, fortunately, nobody has proposed) that would purport to make one interdisciplinary "science" out of nuclear, atomic and plasma physics, photo- and electrochemistry, electronically-active solids, coal mining, undersea oil prospecting, fuel technology and power plant engineering, would obviously be a spurious creation. As mentioned in the previous ESN citations, there are many new "-ologies" that are being spawned with great frequency these days. It is important for science administrators to determine whether these

are really new interdisciplinary fields or just regroupings, with glamorous new labels, of a conglomeration of well-established disciplines. A major criterion for making this distinction has been pointed out by Blank in the above-cited articles, *viz.*, the truly fruitful interdisciplinary sciences are those where individual disciplines, in dealing with a given problem, offer conflicting models or present a "collision of matrices." (J.H. Schulman)

ELECTRONIC DETECTION OF AVALANCHE VICTIMS

Several hundred people get buried under snow avalanches every year and many die of suffocation. In this article we shall show why several proposed solutions of the problem of avalanche-victims detection are not feasible and shall then describe one which promises to be successful.

Because speed and reliability are of paramount importance in locating avalanche victims, efforts in the past decade have been directed toward electronic methods. One method was to detect the electromagnetic radiations from the human body by radiometry. The 10^3 - 10^4 MHz frequency range appeared appropriate for several reasons. At higher frequencies the attenuation of the snow would be too high; and at lower frequencies an antenna with the necessary spatial resolution would be impractically large. Moreover, the 10^3 - 10^4 MHz range is in the microwave band where very sensitive radiometers for thermal-radiation measurements have been developed for radio astronomy.

The central idea of radiometric measurement for the detection of avalanche victims is that the effective radiation temperature of the human body is different from that of the snow-covered ground. It has sometimes been suggested that the human body emits an electromagnetic radiation in the microwave region of an intensity higher than that due purely to thermal radiation. If this be true, it should be possible to identify the frequency range of this characteristic human radiation. However, a five-year experimental study at the Royal Institute of Technology (RIT) in Sweden has apparently failed to do so. The work was carried out at the Division of Electromagnetic Theory in the Electrical Engineering Department under the direction of Professor B. Enander, Head of the Division, with the assistance of G. Larson who is completing his Doctor of Technology degree.

All objects emit electromagnetic radiation (noise) because of the random motion of their interior electrical charges. The intensity of this radiation is governed by Planck's radiation law. For matched systems and at frequencies below, say, 100 GHz (10^{11} Hz), an approximate expression for the available power, $P_a = kTB$, is obtained. In this well-known expression, k is the Boltzmann constant, T the absolute temperature in K, and B is the frequency bandwidth in Hz. Any characteristic human radiation must therefore manifest itself as a part of a total radiated power greater than P_a. At very low frequencies, in the region under 1000 Hz, the human body generates electromagnetic fields of intensities many orders of magnitude higher than P_a. These fields include EEG (electroencephalographic), EMG (electromyographic), and ECG (electrocardiographic) signals. They are frequently used for diagnostic purposes in medicine; but the signals are too weak and the frequencies too low to be useful for detection at a distance. At infrared frequencies (10^{14} Hz), measurement of thermal radiation from the human body is also used as a diagnostic tool. Breast cancer, for example, can be detected at an early stage by using a scanning radiometer which measures the surface thermal radiation from the skin. This, again, is not a suitable method for the detection of snow-covered avalanche victims.

Since the power level to be measured at RIT was of the order of 10^{-14} to 10^{-20} W, a very sensitive microwave radiometer with a suitable electrode or antenna was needed. The simple radiometer consisting of a receiver front-end, a square-law detector, a low-pass amplifier, an integrator, and a recorder cannot be used because its sensitivity is limited by the gain fluctuations of the receiver. The RIT group used a Dicke radiometer which eliminated the effects of gain instability by a modulation principle. The radiometer input was switched between the test object and a matched comparison-load at a frequency of

2 Hz, which is higher than the highest significant frequency component of the gain variations. If the power emitted by the object is different from the noise power of the comparison-load, a modulated signal with the switching frequency will appear at the detection output.

Two types of electrode were used. For the 0.1 - 10 MHz frequency range, commercially available ECG disc electrodes served well. However, at higher frequencies these discs would act as broad-beam antennas and pick up extraneous radiations from the surroundings. An improved coaxial electrode was useful for the 0.1 - 100 MHz range. At still higher frequencies, a small loop antenna matched to the human body as a dissipative medium was found to give satisfactory results. The accuracy of RIT's measurement system was about ± 3K. Experiments have been performed on humans by the RIT group for the frequency range 0.1 - 2200 MHz. Their radiometer results have shown radiation intensities that correspond, within the experimental accuracy, to the thermal radiation of a non-biological body at the same temperature. In other words, they have found no experimental evidence that people emit anything but black-body radiation, aside from the physiological exceptions noted above.

The RIT group has also investigated the feasibility of detecting avalanche victims by microwave radiometry. A switched Dicke radiometer was set to operate at 1410 MHz with a bandwidth of 5 MHz. Since this frequency band is reserved for radio astronomy, it is free from interference by man-made electromagnetic signals. The antenna was a 0.6-m paraboloid mounted 1 m above the surface of a snow-covered field. The snow depth was about 0.8 m and the snow density was approximately 400 kg/m^3. As the antenna and the radiometer moved along a 50-m track, the recorded radiometer temperature varied in the 140-200K range. By comparing the outputs of two neighboring antennas, the recorded temperature difference along the track varied rapidly over a 20 K range. When a person was placed in the snow, the radiometer temperature changed by only about 10 K when the antenna was directly above the person. Since this temperature change was small compared with the extent of natural radiometric temperature variations of the uneven ground, it would not be possible to detect a human being under snow under the given conditions.

Obviously a stronger signal from the buried victim is needed for positive detection. With this in mind, P. Fuks of RIT has designed a transponder to be carried by everybody in avalanche-prone areas. The transponder is a very light and thin 2-inch flexible square plate with printed loop antennas and associated circuits. It responds to a 438-MHz searching signal with a 600-MHz transmission. The searcher carries a backpack which contains a 438-MHz transmitter and a sensitive 600-MHz receiver. An aluminum searching stick is used on which are attached two perpendicular Yagi-Uda antenna arrays with folded dipole with a single parasitic reflector element. The entire searcher's package weighs 10 kg. At present the transmitted power is 5 W. The transponder has a 3-μW output which is sufficient for detection at a distance of 3 m. Positive detection is registered by a red light on the searching stick. Fuks is now working to increase the transmitter power to 30 W and to reduce false-detection probability due to coupling between the transmitting and receiving antennas. Until a better solution is found, a transponder system now appears to be the only reliable method for the electronic detection of victims in a snow avalanche. (D.K. Cheng)

OCEAN SCIENCES

FRENCH MANIPULATORS

The center for Nuclear Studies of the Atomic Energy Commission of France is located at Saclay in the suburbs of Paris. Recently I had the opportunity to visit the Equipment Section for Hostile Environments and speak with the Section Chief, M. Jean Vertut. This group has for years been developing manipulators and remotely controlled vehicle systems of many types.

In 1972, for example, a radio-controlled rescue vehicle (Virgule) was developed to operate under emergency conditions in and around nuclear facilities. It is a four-wheeled vehicle, capable of operating in any

direction, on which was mounted a bilateral master-slave manipulator with a lifting capacity of up to 30 kg, depending upon the position of the manipulator arm. An improved version of this vehicle was completed in 1974, incorporating an electronic master-slave manipulator (the MA 22) which has bilateral positional servo-control and force-feedback. This modified servo system includes a pilot with a current limiter which prevents the possibility of overload, thus eliminating the risk of damage due to excessive strain imposed by human error, inherent in earlier mechanical manipulators.

At the present time ERIC II, a new remotely-controlled undersea vehicle, is being developed. This vehicle will have a 2000 ft. depth capability and will operate on a tether out of an undersea garage which, in turn, is operated on a tether from a surface mothership. The vehicle will contain two television cameras and a pair of force-reflecting bilateral servo manipulators. These six-degree-of-freedom manipulators will be constructed of stainless steel, titanium and aluminum. The writer had the opportunity to operate the laboratory model of this manipulator and found it has a bit of backlash, a problem which Vertut says is now 90% solved. The ERIC II system will require two operators, one for the vehicle and one for the manipulators which will be able to handle up to 44 lbs in any position. This program is a cooperative effort with the French Navy. However, the system is also being designed for use in the recovery of manganese nodules. It is expected that the vehicle will be completed in 1978, funding permitting.

A second device under development is a new bottom-crawling vehicle currently being tested in a shallow tank. The tank was filled with muddy water which served two purposes. One was to simulate various types of sea bottom and the other was to obscure the actual mechanism used for bottom traction. Vertut explained that he could not reveal the nature of the mechanism at this time as the patents are still pending, but that the details will be released in about six months. I was able to watch it move about while it was being cable controlled by Vertut. It moved quickly and with a high degree of maneuverability. Although this was a relatively small model, it could handle an additional 200 pounds of weight on the top without the mobility being affected. The vehicle can be controlled either by cable or ultrasonically.

Vertut mentioned that he is continually facing the problem of selling unmanned systems to organizations which historically are oriented towards manned systems. This problem exists in most countries involved with this technology and reflects the usual difficulties of combating vested interests.

In general Vertut sees numerous underwater applications for remotely controlled systems if industry chooses to utilize the state-of-the-art in manipulator development. With properly designed manipulators we should be able to inspect underwater facilities, pipelines etc.; to weld, cut with various torches, and to handle a variety of tools, shackles, and related equipment. (J.W. Miller)

SECOND INTERNATIONAL HOVERING CRAFT, *HYDROFOILS AND ADVANCED TRANSIT* SYSTEMS EXHIBITION & CONFERENCE - TOO LITTLE, TOO SOON

The first International Hovering Craft, Hydrofoils & Advanced Transit Systems Exhibition and Conference was held in Brighton, England in May 1974 and was generally considered to have been a signal success. Although several firms and organizations voiced the opinion that May '76 would be too soon for the next one, in that there would be very little new to talk about or display, *HOVERING CRAFT & HYDROFOIL* magazine of London launched conference No. 2 in Amsterdam this May. In this writer's opinion, the objectors were right.

Though an international affair, the British dominated it: RADM G.W. Bridle, RN, Assistant Controller of the Royal Navy, opened the Military Day; and 26 of the 47 exhibits, 56 of the 166 delegates, and 18 of the 42 papers were British. The host country maintained a low profile, with one exhibit, eight delegates and no papers. The US was represented by five exhibits, 37 delegates, and 11 papers.

Much that was at all newsworthy was bad news for Britain. The French NAVIPLANE N500 papers and exhibit were the stars of the show and

heightened anticipation for a Channel competition with SRN-4 British Hovercraft. It was announced that two Boeing JetFoils would be placed in service across the Channel from Tilbury to Ostend in the near future. A Westmaran 160-passenger catamaran built by Westermoen Hydrofoil of Norway was demonstrated at Amsterdam flying the British flag because it was to be delivered to a Glasgow operator after the show. The managing director of British Rail Hovercraft Ltd whose cross-Channel service is operating in the red presented a paper largly blaming the SRN-4 for its woes, countered by a paper presented by the general manager of Hoverlloyd, a Swedish cross-Channel operator, showing how he operates in the black with SRN-4. The managing director of Airavia Ltd presented a paper describing the successful operations of its Russian Raketa hydrofoils on the Thames to an audience who could recall that London Hoverservices, plying the same Thames route with the British HM2 Hovercraft, had gone into liquidation in October 1974. Predictably, during coffee breaks and at informal gatherings at night, British colleagues lamented that they were selling their know-how and reaping a sorry return.

The Military Day was especially disappointing: USSR, a country which could contribute much of interest, was absent (the only representation from the Eastern Bloc consisted of two Yugoslavs and one Pole in the audience), and the US chose not to comment on its military hovercraft and hydrofoil programs, which left little else to discuss. In fact, Dr. Frank Barnaby of the Stockholm International Peace Research Institute helped fill up the day by presenting his paper urging the need for control of the ever-increasing trade in arms; considering the make-up of the audience, this was not exactly preaching to the choir.

The picture of the formal proceedings that I paint is admittedly negative. However, it is considered that much benefit was derived from the opportunity for the participants to meet on neutral ground for discussion and agreements; much government-government, contractor-contractor and government-contractor interaction was in evidence, and some contracts definitely resulted. The informal proceedings may well have provided the *raison d'être* for the formal exhibition and conference.
(CDR. H.M. Jordan)

THE FIRST INTERDISCIPLINARY CONFERENCE ON MARINE AND FRESHWATER RESEARCH IN SOUTHERN AFRICA

From 5-10 July 1976 more than 300 scientists assembled at the University of Port Elizabeth, Republic of South Africa, to discuss the state of their knowledge of marine and freshwater research in the Southern Africa region. New facilities at the University provided excellent support for this interdisciplinary conference. Overall organization and support were excellent. Scientific sessions were divided into three categories: five plenary sessions, 25 separate workshops, and 81 poster papers. Microfiche was used throughout, from the circulation of the first abstracts to the distribution of the final proceedings just before the Conference began. Microfiche readers were provided for attenders, so that one might review any particular paper at any time during the conference. The majority of participants were from the Republic of South Africa, with a sprinkling from the UK, the US, Israel and Rhodesia. The dominant languages of the working session were English and Afrikaans.

The plenary sessions were designed to familiarize the interdisciplinary audience with developments in the related fields of marine science. The first was devoted to ocean engineering, and Mr. J.A. Swinborne reviewed South African progress. As the second speaker, Prof. Wiegel (Univ. of California) pointed out, South Africa has been one of the leaders in design aspects of coastal engineering. The third plenary speaker, Mr. J. Rossouw, reviewed the problems of estuary mouths along South African shores. A major task, it seems, is to keep the mouths open under the barrage of wave energy which makes the Indian Ocean and the South Atlantic coasts of South Africa among the most energetic on the globe. Their efforts are not completely successful during the stormiest part of the year.

The limnology of inland waters was discussed in the second plenary session. Prof. B.R. Allanson (Rhodes University) gave the keynote address, emphasizing the physical limnology in the coastal lakes along the South African littoral. Physical limnology is rather new to South Africa, so that his talk created much interest

and will probably stimulate research in this area. Two other plenary sessions were devoted to biological, physical, and geological oceanography. A great amount of activity is going into marine geology and geophysics. There was some suggestion that S. African geological oceanographers were devoting too much time to deepwater studies. Many sessions were indeed devoted to deep ocean basins in the Southern Ocean, and the complaint was that not enough attention is being devoted to the narrow continental shelves. Nevertheless, the Geological Survey has begun a fairly extensive program on the S. African continental shelves. Incidentally, oil exploration has begun on the Agulhas Bank off the southern coast, where the shelf is widest.

Prof. Adrian Gill (Cambridge University) reviewed ocean modeling in a plenary lecture which was extremely well received. The talk was of special interest to the group in light of the large financial and scientific interest in the Benguela upwelling region off the W. coast of S. Africa, which supports lucrative fishing industries. The scientists are trying to understand the relationship between upwelling and the migration of commercial species.

In the plenary session on physical oceanography, Mr. Frank Anderson [the new Director of the National Research Institute of Oceanography (NRIO), Council for Scientific and Industrial Research (CSIR)], reviewed physical oceanography for the edification of the biologists and geologists. He outlined the developing program in South Africa including continuing interest in the Agulhas Current and the Benguela upwelling system.

The final plenary session was devoted to problems of marine pollution, an area in which S. Africa has taken a keen interest. Mr. W.D. Olaf (CSIR) reviewed pollution arising from man's usage of coastal seas. Oil pollution, especially that arising from passing tankers on the Cape route, is particularly important to S. Africa. Much environmental and biological research is being done on pollution of beaches and coastal waters. The keynote speaker for this session was to have been Dr. A.F. Bartch (US Environmental Protection Agency), who was unable to attend. His presence was sorely missed since S. Africans considered this to be a high point of the Conference. Dr. J.K. Basson (Atomic Energy Board) discussed the development of atomic energy in the Republic and the ensuing problems of thermal pollution and radioactivity in the marine environment. Apparently a commitment has been made to construct a nuclear energy plant on the Melkbosstrand, about 70 km N. of Capetown on the Atlantic coast. An environmental study has been underway for about two years on nearshore currents, diffusion processes, and general circulation in the coastal waters. This is of some considerable scientific interest. Basson attempted to assure the scientific community of the lack of danger in this development. I'm afraid he indulged in some wishful thinking; people who oppose nuclear development would not be too convinced. I was surprised by the lack of discussion; at such a time in the US there would have been a brouhaha as a result of this planning. It should be pointed out, however, that recent political developments on the northern frontiers have eliminated some long-range plans for a considerable amount of hydroelectric power. Thus there is something of a no-holds-barred approach to developing nuclear energy as soon as possible.

In the poster sessions, which constituted the remainder of the meeting, 10 papers were devoted to problems in ocean engineering, 7 to marine geology and geophysics, 13 to physical oceanography, 4 to marine pollution, 21 to limnology and 23 to marine biology. This preponderance of activity in the biological areas of marine science is common throughout the world. The active research into the structure, distribution, and origin of the sediments on the S. African continental shelves was illustrated in four of the poster papers in marine geology. G.K. Birch, J.M. Bremer, J. Rogers, R.V. Dingle, G.J. Moore and J.M. Bremner presented four papers on their first studies of the distribution of sediments on the continental shelf and shallow seismic interpretation of the structures of the shelves. We can expect soon to see much more of their work. Dr. Nils Bang, whose work is well known to American physical oceanographers, talked about the southern Benguela upwelling system. Bang has recently been assigned to the East Coast Laboratory in the NRIO, where he is working on currents in

the Indian Ocean. It is hoped that he will be able to resume his upwelling studies later.

Prof. Berg Fleming (Univ. of Capetown) presented some data on a sand-wave field discovered on the southern shelf using side-scan sonar. He is measuring rates of migration and analyzing the flow field over these waves, which seem to be driven by the Agulhas Current. An area of interest to South Africans is the use of satellite-tracked buoys to study the characteristics of the major currents along the S. African shelves. They have had considerable success using the French satellites and look to the NIMBUS for continued tracking. Mr. Martin Grunlingh showed interesting trajectories of currents based on tracking by NIMBUS 6. In particular, the theorized retroflexion zone on the Agulhas Bank where the Agulhas Current is thought to turn back east after rounding the Cape was brought out very clearly. This will be a continuing effort, but the satellite approach is expensive, and Grundlingh's group is interested in moving into high-frequency tracking of drogues using shore-based stations.

Several papers were given by Messrs J.K. Mallory, N.P. van Ieperen, and Frank Shellington on the characteristics of surface waves near Capetown and along the Atlantic shelf N. of Capetown. Most of these data result from studies associated with the nuclear power plant to be established along that stretch of the coast. Shellington showed energy density spectra, distributions of wave height, and seasonal wave climate. The data acquisition system uses both the Waverider buoys and their telemetry systems mounted on a tower which was installed in about 20 m of water out in these very rough seas. This tower measures surface waves, temperature and some salinity factors. Current meters are deployed nearby. The severe environmental conditions present difficulties with this equipment.

Dr. L.V. Shannon, (Sea Fisheries Branch) described the application of physical oceanographic data to an important fisheries problem. The apparent random movement of the large S. African mackerel onto and off the Atlantic shelf was explained by some good monitoring of the water mass characteristics. When the Benguela upwelling slackens, the Atlantic water moves onto the shelf, carrying with it this mackerel, a highly valued cash crop in the African market. More rigorous monitoring of the offshore water masses is recommended so as to improve utilization of this resource. The airborne radiation thermometer (ART) is being used to very good effect in studies of S. African coastal and shelf waters. Mr. A.F. Pierce (Durban NRIO lab), now the head man in the Durban oceanography laboratory, presented very detailed surface thermal maps of the Agulhas Current region off the Indian Ocean coast. The correlation with current dynamics seems to be very good. The motive, once the correlation is understood, is to use airborne radiation thermometry so as to be aware of, if not to predict, the behavior of the Agulhas current.

Some work by Mr. C.A.R. Bain, while classified as marine pollution research, is actually coastal oceanography which may be applied to monitoring of possible thermal pollution from the proposed nuclear power plant on the Melkbosstrand. Bain showed thermal data maps and drogue trajectories based on radar tracking of corner reflectors on drifting window-shade drogues. The data seemed to indicate inertial loops of the correct period, about 20 hours, which is surprising considering their proximity (a few kilometers) to the coast.

More than half the poster papers were from the limnological and biological groups; much research is going on in inland waters and lakes, of which there are very few in Southern Africa. A good deal is going on in man-made lakes behind dams and hydraulic structures. These new resources are being heavily utilized and intensively studied, and the colonizing populations are under close scrutiny.

Mr. Bruce Gunn (Capetown Univ.) discussed the dynamics of a coastal embayment along the Cape's Atlantic coastline, with a rather convincing argument that edge waves are set up by the large swell entering the embayment according to LaBlond's model, thus controlling the circulation pattern in the area. The data taken by radar tracking of drogues seem to agree rather well with the model. Gunn is continuing this work, which is connected, at least financially, with the thermal pollution studies.

The workshops were very successful. The informal atmosphere led to good give-and-take. In those in which I was directly involved, such as the

ones on the Agulhas-Benguela currents and the mixing area of the south coast, there was heated discussion and speculation on what we do and do not know. The only real data are from a few STD drops and the satellite buoy tracking of recent years. It came out that we really do not know the source of the water that goes into the Benguela Current. The driving force for the transient upwelling is also unknown, although Bang still defends his idea that it is the sharp gradient in the wind stress from the coast out over the shelf. The workshop on oceanographic instruments was more of a show-and-tell situation in which people described their recently acquired instruments. There was hope that satellite data would be of great future assistance.

A list of attenders, which will identify scientists in the RSA with common interests, is available upon request to this author. (S.P. Murray, Louisiana State Univ., Baton Rouge)

A NEW STRATEGY FOR ACADEMIC INVOLVEMENT IN MARINE TECHNOLOGY?

Traditionally the level and nature of academic involvement in a given scientific area has been determined very largely by scientific interest, the various resulting balances only being modified to meet situations of acute national or other emergency when the need has been paramount. In recent years shortage of resources and accompanying economic and technological needs have resulted in an increasing number of calls for academic assistance and substantial modification of this traditional process. For some time in Britain exploitation of offshore hydrocarbon deposits has been considered by many as the panacea to the nation's economic problems. Inevitably calls for assistance in the marine technology field from the academic community have followed. Nowhere has this need for assistance been felt more acutely than in industry. Unfortunately the industry-academic interface has never been particularly well developed in Britain.

Recognizing the need for academic involvement in a "Report on Marine Technology" issued in August 1973, the Science Research Council--which is primarily responsible for support of research in the universities and other academic institutions--drew the attention of the academic community to the requirement for research and training assistance and to the opportunities presented it to meet a national need. Response, however, was not great, and after extensive consultation with the various parties concerned a decision was made to set up a Special Task Force to advise on a suitable strategy and to identify the resources needed to meet the requirement.

Set up in October 1975, the Task Force chaired by Dr. J. Birks of British Petroleum reported as early as April 1976, consonant with the urgency of the problem. The time available to the group permitted detailed attention only to the shorter term problems (1980s and mid '90s) faced in exploitation of offshore hydrocarbon deposits as typified by British North Sea activities. They considered this, however, as a realistic base for a longer term and broader based marine technology program appropriate to university involvement. The Task Force report "Marine Technology--The Report of a Task Force of the Engineering Board" (SRC, Apr 1976) makes a number of strong recommendations and comments in terms of objectives, management, coordination, organization, priority areas and resource requirements. Its various appendices provide a thumbnail sketch of current efforts and available facilities, and of the views of various bodies as to the desirable nature of an SRC marine technology program.

Calling for an increased level of support by the SRC in marine technology and a well-coordinated national program, the Task Force stresses that a primary SRC objective should be the achievement of a close working relationship between the academic institutions and industry. They cite a number of examples of successful university-industry interaction achieved outside the UK and specifically by Rice University and the University of California (Berkeley) in the US, and by the Norwegian Institute of Technology at Trondheim University.

To support the evolution of a coordinated national marine technology program they stress that the SRC should ensure that its longer term research and training programs are integrated with existing civil and defense efforts. They suggest that

changes in the current SRC system of management and administration will be necessary to achieve such a program. Current British efforts in the civil field include the programs of: (1) The Marine Technology Sub-Committee of the Department of Industry's Ship and Marine Technology Requirements Board (SMTRB); (2) The Department of Energy's Offshore Technology Board (OETB); (3) The National Environmental Research Council (NERC); (4) The Department of the Environment's Hydraulics Research Station (HRS) and Building Research Establishment (BRE). In addition the Ministry of Defence supports considerable work in academia as well as work in its own establishments.

To implement a program the Task Force further recommends the establishment and support of a limited number of centers of expertise although the program should not be exclusive to these centers. Institutions suggested as possibilities for this role are Glasgow, Strathclyde, Heriot-Watt, London and Newcastle, where basic interests exist or are developing.

Research areas recommended for support in an SRC-funded program are in order of priority: (1) Safety & instrumentation, (2) Underwater work & pipelines, (3) Floating craft and environmental forces, (4) Marine structures and materials, (5) Power generation & transmission, (6) Economics. Recognizing that these broad areas cover work already being pursued in existing government and industrial programs, and which includes problems of both urgent and longer term interest, the Task Force stresses the need for their inclusion to promote essential interaction.

Funding requirements for an SRC program to cover the oil- and gas-related technology area principally covered by the Task Force are estimated at about £2 M for the first year rising to some £6 M in 1981/2 with an additional £10 M for major facilities. Beyond this, other marine technology areas will require additional funding. By comparison, the current funding of marine technology work by the SRC is no more than a few hundred thousand pounds annually.

The Special Task Force's report has been published to encourage participation in a nationally coordinated program and to seek comment for a full program proposal. Clearly, if the strategy is to have a major impact on exploitation of hydrocarbon deposits in the next decade, implementation must be rapid. (LCDR J.D. McKendrick and A.W. Pryce)

PHYSICS

THE THIRD INTERNATIONAL CONFERENCE ON TOROIDAL PLASMA HEATING

One of the major problems associated with the Tokamak approach to controlled thermonuclear fusion is how to heat the plasma to an ignition temperature of 10 keV, or 10^8 C. A Tokamak is a toroidal plasma device in which the toroidal magnetic field--generated by external field coils--and the poloidal field--generated by the large plasma current (hundreds of kA in present Tokamaks and several MA in future reactors)--both serve to confine the plasma. As originally envisioned, ohmic dissipation of the plasma current would also provide the heating. It is now apparent, however, that because the plasma resistivity decreases rapidly with increasing temperature, ohmic heating alone cannot do the job, and supplementary heating is necessary. The importance of this problem is underlined by the fact that there were three nearly simultaneous international conferences on the matter: the Third International Conference on the Heating of Toroidal Plasmas in Grenoble, France, 28 June-2 July, organized by T. Consoli and coworkers; the Gordon Conference on plasma heating during the same week in Santa Barbara, California; and the International Summer School on Heating of Toroidal Plasmas in Varenna, Italy, to take place in September 1976.

There is a great deal of activity in this area. At least eight different ideas for supplementary heating were proposed and discussed at the Grenoble conference. They are neutral beam injection, ion cyclotron resonance heating (ICRH), lower hybrid heating, shear Alfven wave heating, electron cyclotron resonance heating (ECRH), electron beam injection, ion beam injection, and cluster injection. Since only one of these schemes has to work, there is considerable optimism for Tokamak. In the remainder of this report, I shall discuss each scheme briefly.

At this time, neutral injection is certainly the favored scheme. It has worked well on existing Tokamaks, and there are several ideas of how to overcome the major problems involved in neutral injection into larger

Tokamaks. Dr. R. Dei-Cas (TFR, Fontenay, France) reported doubling the ion temperature to 1.7 keV in the TFR Tokamak by neutral beam injection yet there was no measurable electron heating although theoretically a large fraction of the neutral beam's energy should be deposited in the electrons. Dr. F. Perkins (Princeton) reported similar results for the ATC Tokamak with no observable degradation in confinement.

Neutral beam heating for larger Tokamaks becomes much more difficult. As Dr. E. Thompson pointed out, for energies above 80 keV for protons and 160 keV for deuterons, the efficiency of beam production falls off very quickly. However, beams of such energy will not propagate to the center of a large Tokamak, but rather will be ionized (and therefore deposit their energy) at the edge.

Two schemes to circumvent this difficulty were presented. Dr. D. Jassby (Princeton) suggested ripple injection. Here, the toroidal magnetic field has a slight ripple. The beam is injected so that when the neutral atom is ionized, it is trapped in the field ripple. Then cross-field drifts will transport the energetic ion from the edge of the plasma to the center. In another talk, Dr. J. Sheffield of the Joint European Torus (JET) design group suggested a scheme using the neutral beam to supply not only energy, but also particles. The idea is that the neutral beam is always deposited on the edge of the plasma, but the plasma expands radially (because of the particle flux from the beam), from nearly zero radius until it fills the vacuum chamber. Also, both Sheffield (JET) and Dr. H. Shirakata (JT60-large Japanese Tokamak) emphasized that both Tokamaks are being designed to promote maximum flexibility of auxiliary heating schemes.

The other scheme which seemed to be favored at the meeting was ICRH. Since the ion cyclotron frequency is low (about 25 MHz in ATC), waveguides are not generally used, but coils to transmit this power have been built successfully. Perkins displayed experimental data showing that 90 W of rf power at twice the ion cyclotron frequency for 10 ms doubles the ion temperature from 200 eV to 400 eV. Also, there are energetic ions which form a higher temperature tail to the ionic energy distribution function. Two other machines also showed evidence of ICRH. A. Iiyoshi (Japan) showed experimental evidence that 130 W of rf power raised the ion temperature from 20 eV to 40 eV at low plasma density. At higher density, the ion heating fell off, but electron heating picked up. At the highest density ($N_e \sim 10^{13}$), electrons were heated from about 25 eV to about 75 eV. Iiyoshi attributed this to a change in the character of the plasma mode at higher density. Dr. C. Sprott (Wisconsin) showed that the ion temperature in the University of Wisconsin octopole can be raised from zero to about 350 eV by ICRH. The TFR group in Fontenay has not yet injected high power into their machine, but has done a number of interesting preliminary experiments at low power.

The other mechanism which was discussed at some length was lower hybrid heating, that is, heating by pumping in microwave power at the lower hybrid frequency. This is potentially attractive because the power sources are readily available and the power can be coupled to the Tokamak with small waveguides. The experimental results were not nearly as encouraging. Perkins, who also gave a review talk on supplementary heating, showed experimental data for ATC which showed no ion heating parallel to the magnetic field. There was no clear change in the electron temperature, as determined by laser scattering. However, there was enhanced cyclotron radiation at two to four times the electron cyclotron frequency. This was interpreted as a nonthermal tail on the electron distribution function. Roughly 10% of the rf power goes to forming this tail. The other 90% is unaccounted for, except that Princeton experimentalists know that 80 to 90% of the total power does go from the waveguide into the Tokamak. The other experimental results reported were quite different but equally discouraging. Dr. J. Wegrowe reported on lower hybrid heating of the WEGA Tokamak in Grenoble. The energy was typically deposited in the ions on the edge of the Tokamak, and from there it was deposited very quickly on the walls or limiter. Only about 10% of the rf power gets into the center, where it raises the ion temperature by about 20% and does not heat the electrons. There is no evidence of energetic electrons either.

There is experimental evidence that parametric instabilities, which are instabilities induced by

oscillating electric fields, may be responsible for power being deposited on the edge. Decay waves are often observed. There were several theoretical papers on parametric instabilities and the effect of energy deposition on the edge by G. Hasselberg (Jülich), J. Wersinger and A. Kritz (Lausanne), E. Ott (Cornell), and F. Santini (Frascati). G. Schmidt (Stevens University) gave a review talk on parametric instabilities. Both Schmidt and Ott emphasized that while initial results may be discouraging, there are still many things that can be tried to suppress parametric instabilities and thereby improve the results.

The preceding three heating schemes received by far the most attention at the Conference. Most of the work in auxiliary heating seems to be in these areas. I shall now discuss quite briefly the remaining five areas, starting with ECRH. Traditionally the problem with ECRH is that powerful sources at the necessary high frequencies are not available. However, in the past few years, sources capable of delivering up to 70 W at wavelengths of 5mm have been developed at the Kurchatov Institute in Moscow. Dr. Y. Arsenyev told of the development of these sources.

Another scheme mentioned by several people was shear Alfven wave heating. Radio frequency power coupled from outside the Tokamak can be absorbed by the plasma at the radial position where $\omega = k_{||} v_{Alf}$. This scheme has been discovered within the past few years; furthermore, because of the low frequencies involved, the power can only be coupled to the Tokamak by quite large coils. Therefore not much work has been done in this area. Dr. L. Chen (Princeton) discussed the theory of this process, and Iiyoshi presented experimental results for the heliotron which showed an increase in ion temperature from about 20 to 40 eV during a 300-W rf pulse. The electron temperature quickly shot up from 100 eV to 200 eV and then quickly came back down to 100 eV while the rf pulse was on.

Two other heating schemes have received some attention in the US. Dr. R. Sudan gave a review talk on electron beam heating. If the beam gets into the plasma, the heating probably takes place by the two-stream instability followed by a period of slower parametric instabilities and soliton formation. The problem, of course, is how to get the beam into the plasma across the magnetic field. It appears possible to get a very intense beam into the toroidal vacuum chamber, but not into the plasma.

A related idea, discussed by me, is to use an intense ion beam instead of an electron beam. Since ion beams can be easily charge-neutralized, they can propagate across the vacuum magnetic field. Mechanisms by which the beam energy could be deposited in the plasma were also discussed.

A final scheme, studied in Europe and Japan, but not in the United States or the Soviet Union, is cluster injection. Dr. Bottiglioni (Fontenay) gave a review talk on this subject. He proposed injecting small, singly charged crystals (clusters) of perhaps one hundred to one thousand atoms of solid hydrogen, accelerated through a voltage of 5 to 10 MeV, into a Tokamak. Because of the very small charge-to-mass ratio of a cluster, its Larmor radius is quite large, and it should be possible for a cluster to penetrate to the center of a Tokamak plasma and deposit its energy there.

I felt that the conference was very successful. There was a free interchange of ideas by scientists from all over the world. The next few years should see important new experimental results on supplementary heating of the new generation of larger Tokamaks. There was general agreement that another such meeting should be held in two or three years.
(W.M. Manheimer, NRL, Wash.,DC)

LASER PLANS AT FRASCATI

The Italian government's major nuclear energy and high-energy physics research center is the Laboratori Nazionali di Frascati, located in a rural Roman hill town. The Frascati research center is under the patronage of two agencies, the National Nuclear Energy Committee (CNEN) and the National Nuclear Physics Institute (INFN). Nominally, CNEN is the agency responsible for applied research in nuclear energy while INFN promotes basic research in high-energy physics. Until recently, these two national agencies have supported Frascati's research without too much regard to the separation of staff and equipment between

them. Now the Frascati research center is undergoing a reorganization into two segments, physically as well as administratively. Each part is expected to reflect the aims of CNEN and INFN separately. This split has had its expected difficulties (see ESN 30-4:179) magnified, perhaps, by the recent Italian political and economic uncertainties. However, through the years, Frascati has acquired an excellent scientific reputation which should sustain it for the future. Recent articles (ESN 29-11:454 and 30-4:179) have reported on the high quality research in plasma physics and low temperature physics at Frascati.

Now there is a bright spot in Frascati's plans. Planned are several large laser programs for both sides of the new organization. Taking the current opportunity to phase out certain research efforts that were becoming uncompetitive to research in other countries, they have started two ambitious laser projects. Frascati has a brief history in lasers. Prior to 1970, a program was undertaken to study high-power laser beams interacting with materials, but after initial work on a Nd:glass laser having a goal of 30 J in 10 ns, the effort was aborted because of limited funds. In 1976, according to Dr. Alberto Bracci, director of the new laser effort for CNEN's Frascati group, an extensive CO_2 laser development was started. A pulsed CO_2 laser system to deliver 1 kJ in 1 ns has been under construction since January. This laser is the initial project in a five-year plan to build a 10 kJ CO_2 laser facility for laser-plasma studies. While the precise laser-plasma experiments to be undertaken at Frascati are indefinite, Bracci feels that they must concentrate initially on laser development which, he states, "begins from zero." That statement is not exactly correct since the scientific staff on the project have much experience with particle accelerators and other high-energy physics devices which they can put to good purpose in the design and use of electron beams and high-current power supplies required for the CO_2 lasers. Yet the laser field is new to them.

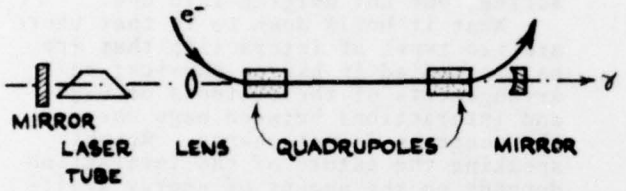
The design of the 1 kJ CO_2 laser adopted by Frascati is a single-transverse-mode oscillator driving four parallel amplifier chains, each to deliver 250 J. The amplifiers will be pumped by electron beams, while the master oscillator configuration will be either electron-beam pumped or TEA (transverse electrically-excited atmospheric). Both types of oscillator have been built under the direction of Dr. Ubaldo Bizzarri and are currently under test, initiating many of Frascati's staff to lasers. It is apparent that their beginning efforts in CO_2 lasers are following in the footsteps of the developments at US and UK laboratories.

A different and very intriguing laser project is proceeding under INFN's auspices. INFN, who are harder pressed for funds than CNEN, believe that many of their accelerator scientists must adapt to new times. In response, Dr. Gianni Matone and coworkers proposed the use of Frascati's storage ring ADONE to produce 82 MeV photons by backward Compton scattering of laser light with high-energy electrons. Such high-energy photon beams would be quite useful in experimental nuclear and particle physics. They have carefully considered all the technical problems of the Compton scattering experiment, and now the ADONE machine is being made ready for scattering of argon-ion laser light by 1.5 GeV electrons.

Several attempts to study this Compton scattering by lasers have been carried out during the past 15 years. In 1963 both Melbourne [*Phys. Rev. Lett.* 10, 75 (1963)] and Arut Arutyunian [*Phys. Lett.* 4, 176 (1963)] pointed out that background Compton scattering could produce useful yields of high-energy photons. The major experimental trials have been made by the Lebedev Physical Institute [O.F. Kulikov *et al.*, *Phys. Lett.* 13, 344 (1964)] and at the Cambridge Electron Accelerator [C. Bemporad *et al.*, *Phys. Rev.* 138B, 1546 (1965)] where the ruby laser (1.78 eV or 6943 Å) was always used. Without entering into any details we may say that neither of these experiments produced a beam of photons intense enough for use in particle physics research. Another more successful attempt has been carried out at the Stanford Linear Accelerator SLAC producing a 5 GeV photon beam [J. Ballam *et al.*, *Phys. Rev. Lett.* 23, 498 (1969)].

While these previous attempts were characterized by the output laser beam being sent directly against the electrons, in the Frascati project the laser effect will take place in an

optical resonator as long as the ADONE machine's straight section. The improvement that Frascati proposes is the use of an argon-ion laser (4880 Å or 2.54 eV), where the power present in its resonator can be up to 100 times as intense as the output power of a standard commercial laser. A sketch of the laser arrangement with the machine pipe is shown in the Figure.



Problems do arise though in that the laser optics on the machine pipe must be installed at the high vacuum of the storage ring, and the laser mirrors *must* be protected against the coating damage caused by the presence of synchrotron radiation. Another more basic problem is the spreading of the scattered photon energy by the angular divergence of the electrons in the quadrupole regions. Since the scattered photons are emitted in a very small cone along the electron direction and the energy of these photons depends only on the emission angle with respect to the incident electron beam, the collimation of the beam determines the energy spread of the high-energy photons. If Compton scattering occurs in the straight section only, the energy spread of the photons is near 1% of the photon energy, while the spread is five times higher when scattering in the quadrupole section is included. One method of avoiding the quadrupole region is to pulse the laser beam in such a way that photon and electron bunches interact only in the middle of the straight section. To achieve such repetitive laser pulses synchronous with the ADONE frequency of 8.56 MHz, the argon-ion laser will be mode-locked by an acousto-optic modulator with a resonator length of 17.5 m. For the present experiment, the design parameters are 1.5 GeV electrons colliding with 2.54 eV laser photons to produce 82 MeV photons, where the laser power stored in the cavity is 250 W and electron circulating current is 100 mA.

A survey of quantum electronics research in other Italian laboratories will be presented in an upcoming ONR London Technical Report "Quantum Electronics In Italy." (L.C. DeShazer)

QUARKING ON THE BERKSHIRE DOWNS

I am the boy
That can enjoy
Invisibility
--James Joyce

The notion that the strongly interacting elementary particles (hadrons) may not be as elementary as we thought, but rather composed of point-like objects called "quarks," has proved to be very helpful in the understanding of high energy phenomena. The idea of the quark substructure of hadronic matter arises from the observed symmetries among the sometimes large families of particles, all of which except the proton are unstable, produced by the high energy accelerators of the world. (For a concise introduction to the quark hypothesis in its current form, see the article by Sheldon Lee Glashow in the October 1975 issue of *Scientific American*.) Even the amazing new particle, the ψ (psi), alias J, and its relatives, now chiefly being studied as products of the colliding electron and positron beams in the storage ring (SPEAR) at SLAC at Stanford, fit into this scheme by simply adding another type of quark. Never underestimate the ability of a theoretical physicist to reshape his favorite theory to fit the latest experimental observations! Although this may seem more appropriate to an ice cream parlor than a physics laboratory, we now have four "flavors" of quarks, and each flavored quark can at any instant have one of three colors, say red, blue and green. The original three flavors were "up", "down" and "strange", and with the recent rise of a new "new physics", we have "charmed" quarks. (Bear in mind that we have a corresponding set of "anti-quarks" with opposite quantum numbers!) Unfortunately, picturesque as these terms

may be, they do not give one even the slightest clue as to what is actually going on in the labs and in the heads of those arrogant particle physicists. A whole new technical terminology is evolving so that completely new concepts can have names of their own, or at least, almost their own, letting context resolve the ambiguity of whether one is discussing hadrons or ice cream, quarks or quarts.

Lest one conclude that the mysteries of primordial matter have finally been solved, let me hasten to point out that the mysteries have simply been illuminated a little better, and some of them given names. For example, consider the question: "What glues the quarks together?". Gluons, of course! And there are eight of these photon-like gadgets, as required for mathematical consistency. And if one should be so bold as to ask: "Why have not quarks been observed?" or: "Why are quarks invisible?", one would be told: "We have no idea, but we call it 'ultraviolet slavery'!", or: "Because they come in bags of two or three together or not at all!" And along with the many remarkable triumphs of the quark model, there are several theoretical shortfalls, indicating that at least a few mysteries remain to be named.

But the "Quarks-in-Bags" picture is a good way to understand what is going on experimentally now at the big accelerators. Three quarks in a bag are slammed against another three quarks in another bag, and one looks to see what happens. Often one will have many bags emerging from the interaction, but never has anyone produced evidence of more than three quarks in a bag together, and never one quark alone. When a bag of three quarks, say, is struck very hard it may be distorted so badly that it breaks into two, but in that fissioning process, evidently, there is always enough energy to create a quark-antiquark pair, one for each of the daughter bags. For example, a proton consisting of a bag containing two "up" quarks and a "down" quark is hit so hard that one of the up quarks starts to leave the scene. However, as the distorted bag is about to fission, a "strange" quark-antiquark pair is created, so that the departing "up" quark is accompanied by the "strange" antiquark, and the stay-at-home "up" and "down" quarks are chaperoned by the new "strange" quark. The former bag is called a K^+ meson and the latter is called a Λ° hyperon. Thus, in our example, if one hits a proton hard enough one sometimes turns it into two new, unstable particles. But always with no more than three quarks, or antiquarks, per bag.

That is the theory. But can you have "exotic" particles, those that do not obey the rules? You might say: "Of course, the deuteron, or any nucleus, for that matter!" No, those are examples of two bags interacting, but not merging into one.

What it boils down to is that there are two types of interaction that are being studied in hadron physics; rearrangements of the contents of bags and interactions between bags where the contents do not change. Roughly speaking the nature of the interaction depends on the amount of energy available; in the few MeV range we have nuclear physics, pure bag-bag interactions, the hadronic equivalent of van der Waals forces; in the few hundred to a few thousand MeV range, we have intermediate energy physics, in which one has bag-bag interactions as well as some alterations of the contents of the bags. In the high energy regime we have mostly new bag creation and interactions among the quarks of all bags together.

The bare outline of a theoretical structure as described above is thus beginning to take shape. Even if it is on the right track there is a long way to go before it can predict all the details of something so complicated as a bag-bag interaction. When we want to know about this aspect of nature, we must measure it.

The Science Research Council's Rutherford Laboratory, just south of Harwell, on the Berkshire Downs (now part of Oxfordshire) is the center and rallying point for high energy particle research in Britain, especially with the imminent closing down of the electron accelerator, Nina, at Daresbury. Here resides the great hunter Nimrod, an 8-GeV proton synchrotron. I have just spent my sabbatical year there, helping to set up a K-meson beam.

Nimrod straddles the interesting area between the low energy, nuclear physics regime, where bag-bag interactions are important, and the high energy regions, attainable at the SPS at CERN and at the Fermi Laboratory Accelerator, where quark-quark interactions play the dominant role.

With Nimrod one can study particle (bag) production and decay processes as well as the interactions between particles, and one hopes that one can determine if this way of looking at things really holds water.

I spent a very enjoyable and interesting 9 months with physicists from David Buss's group at Queen Mary College (led by Peter Kalmus) who are collaborating with a Rutherford Laboratory group (led by Alan Astbury) in a study of the kaon-nucleon interaction in which the kaon has a momentum ranging from 0.7 GeV/c to 1.4 GeV/c. This interaction is particularly interesting, especially when the positive kaon (K^+) is involved in a collision with a proton or neutron, because the quark model does not allow the two particles to fuse into one bag during the interaction, as can occur, for example, when the pion and nucleon interact. The former interaction should be therefore similar to the interaction of two nucleons which likewise cannot fuse into one bag, if exotic states are in fact forbidden. Another way of describing what is happening is to say that the interaction between two hadrons can occur via intermediate states (resonances) in which momentarily at least all the quarks are in the same bag (like the old "compound nucleus" idea in nuclear physics) or it can occur by the "background" interaction which means that the bags do not fuse even momentarily, the forces involved being collective forces analogous to the van der Waals forces between atoms. The point of all this is that the K^+ must interact with nucleons only via the "background" interaction, whereas the π^+ can interact with nucleons via the same background interaction and via resonances, as well. By comparing these two interactions one can isolate the two different interaction mechanisms (See Jean O. Dickey, *Nuclear Physics* B90, 501, 1975).

Doing a particle physics experiment is usually a very major effort. One doesn't just walk into the stock room, pick up a few items and stick them into some particle beam or other. Our experiment (known as K20 at the Rutherford) is certainly no exception; it is an effort that requires the full-time attention of at least a dozen physicists for three or four years, as well as much expert help from the Rutherford staff, who are very skilled and very helpful. It also requires the latest equipment and experimental techniques that technology has to offer, although sometimes one has to make do with equipment which is not quite the very latest.

To give a clearer picture of what is involved, let me list the major components of our experiment. First we need Nimrod to supply us with about 4×10^{12} 8-GeV protons in half-second pulses 15 to 22 times per minute. Then we must arrange for these protons to strike a very small copper target, say 4 x 4 x 100 mm, thereby producing practically all the particles you've heard about and maybe more, in all directions and all energies less than 8 GeV. Next we must arrange to select out the kaons we wish to use in our scattering measurements. This is done in the same way, almost, that one produces a monochromatic light beam, except the equipment involved is different and bigger; and there are additional complications: with light one need sort only on wavelength (momentum), but with particles we must sort on charge and mass as well. We sort on momentum (wavelength) analogously to the optical case, using the copper target as our point source, quadrupole magnets as our collimating lenses, and bending magnets (dipoles) as our prisms. This selects both the desired charge and momentum, but not the mass, and results in a mixture for positive particles, say, of protons, kaons, pions and positrons. How does one sort on mass? By sorting on velocity in a population that has the same momentum, using crossed electric and magnetic fields (electrostatic separators) whose effects just cancel out for those particles at the chosen momentum whose velocity corresponds to the desired mass. This is, of course, possible because the force a magnetic field exerts on a charged particle depends on its velocity, and the electric force doesn't care. In this way we can prepare a beam of the kaons, almost. The trouble is that pions especially tend to leak through; our beam optics are not perfect, we don't really have a point source, and we start with many more pions than kaons. Therefore one needs an additional filter; we measure the velocity of those particles that make it through our optics, and shut our experimental "eyes" if the particle is not a kaon. For the lower momenta, up to 1 GeV/c we find time of flight between two scintillators

is adequate, above that we use the signal from a Cerenkov device, which gives pulses for kaons and none for pions. We spent most of last year tuning up and developing this technique, and finally this spring we were able to produce several thousand kaons per accelerator burst in a three-percent momentum bite over our desired momentum range.

So we have a K beam. Now what do we do with it? We must then measure the direction of each certified K, using 8 planes of multiwire proportional chambers (MWPCs) before it enters our polarized deuteron target. Oh yes, I haven't told you yet, but we wanted mainly to scatter K^+ off of neutrons, and they really should be polarized as we expect the scattering mechanism depends on the direction to the neutron's spin relative to the scattering plane.

The polarized deuteron target is provided for us by a team under the skillful direction of Dr. Tony Parsons. The technique involved, called "dynamic polarization," requires that one place the deuteron-bearing material, deuterated propanediol, at less than 0.5 K, in an appropriate microwave cavity in a magnetic field of 25 kG. With luck one can get polarizations of 30%. The plan is to determine whether our kaon hits a polarized neutron in one of the deuterons or one of the unpolarized neutrons in a carbon nucleus by the appreciably less kinematic smearing that would occur in the former case compared with the latter. The velocity spread of neutrons inside deuterons is considerably less than that in other nuclei.

Now the fun begins. If there is an interaction, we shall have two or more particles emerging from the target. In the reactions of special interest to us $K^+n \rightarrow K^+n$ or K^0p, only one emerging particle will be charged. With the help of two planes of vertical wire chambers wrapped around the target, five planes of vertical wire chambers wrapped around the target, five planes of wire spark chambers further away, a plane of scintillators, and finally an array of neutron detectors, some liquid, some solid, scintillators, all feeding into a PDP 9 computer, along with the data from the beam MWPCs, times of flight or Cerenkov pulses, etc., we plan to determine the scattering angle and the type of interaction.

Although the primary aim of the experiment is to study KN reactions, it is likely that π N reactions will also be looked at where an appreciable improvement over existing measurements can be made with little additional effort on our part.

Now comes the sad part of my report. This experiment is one of the last experiments to be done on Nimrod. Because of the economic situation in Britain, funding for high energy physics will be sharply cut back in the future. Funds for Nimrod are due to run out by the end of 1978, in order that the British contribution to CERN can be maintained. It will be nip and tuck whether all the planned measurements on K20 can be completed by then.

The announcement of the anticipated closing down of Nimrod comes on the heels of the September 1975 decision to terminate work on EPIC, a 14-GeV electron-positron storage ring. Present plans are to replace Nimrod by an 800-MeV high intensity proton synchrotron ("Son of Nimrod") which would be used primarily as a neutron and meson factory, oriented toward applied research and medical physics. The new project would make use of much of the hardware and personnel made redundant by the demise of Nimrod.

What is it like for an American working at Rutherford? I personally found it quite pleasant, and I would like very much to return some day. I found the standards of performance to be quite high, the atmosphere to be intellectually stimulating, and the personnel universally friendly, helpful and tolerant of the occasional American *faux pas*. I did notice that my attempts to raise the Nimrod control room personnel *via* the intercom system often were ignored, whereas my British colleagues were always answered. At first I was hurt, until I realized that my voice simply sounded like a little more of the usual background static to them, rather than a human voice, as they seemed quite pleased to see me if I appeared in the control room in person. (Howard C. Bryant, Univ. of New Mexico, Albuquerque)

POSITRON ANNIHILATION: FROM QED TO NDT

A conference on positron annihilation may conjure an image of a narrow topical meeting. In fact, the Fourth International Conference on Positron Annihilation (Helsingør, Denmark; 23-26 August 1976; 160 papers; 21 nations) was quite remarkable for its breadth. Its coverage proceeded from considerations and tests of quantum electrodynamics (QED) to techniques directed to the full application in non-destructive testing (NDT). The vitality of the field was demonstrated by its breadth which includes dynamics and mechanisms in chemistry, studies of defects and phase transformations in materials science and solid state physics, biological inquiry, and non-invasive applications for medical diagnosis--and by its growth, reported at the conference by R.M. Lambrecht (Brookhaven) as 18% per year currently.

The positron is the anti-particle of the electron. Its history occupies a noble place in physics. Its existence was predicted as a consequence of Dirac's relativistic formulation of quantum mechanics (1930) as the positively-charged image of the familiar electron. Experimental verification was rapid (1932) and won a Nobel prize for Carl D. Anderson. Thus positron physics is hardly a new area. What accounts for its resurgence? Two facts dominate. The first is experimental. The significant improvement in experimental equipment based on the use of solid-state electronics and computer facilities has opened positron annihilation (p.a.) to a host of investigators who might otherwise not have ventured into this field. Even earlier, a second factor had become recognized: p.a. can be a valuable tool for investigators who maintain only peripheral interest in positrons *per se*. One of the earliest applications of p.a. to condensed material was the investigation of Fermi surfaces in metals, an application which received a good deal of attention at this conference as well.

The conference was held at the L. O. Skolen (Labor Organization School), an ideal location with fine facilities for this occasion. The School houses many conferences throughout the year and provides excellent accommodations for the attenders in a scenic location near the narrow waterways which separate Helsingør, Denmark from Hälsingborg, Sweden. The well designed program proceeded from the more basic to the more applied. The flow of the program guaranteed that participants interested in more applied matters generally attended the more basic papers and *vice versa*. Furthermore, by resorting to poster sessions for most of the contributed papers, the conference arrangers avoided the evils of simultaneous sessions.

This conference, the first since 1973, signaled the increasingly active role now being taken in the field by European laboratories particularly, and by Japan. Curiously, one of the indicators of this new European and Japanese activity was the explicit tributes made at the conference banquet, and in numerous comments, to the central role played over a period of years by Stephan Berko and his collaborators at Brandeis University (Waltham, Mass.). In a banquet address, A.T. Stewart (Queen's University, Ontario), himself a notable long-time contributor, presented the non-existing prize for outstanding work in p.a. to Berko and two of his collaborators (K.F. Canter and A.P. Mills, Jr.) for their basic investigations into positronium.

Positronium is the "element" which consists of an electron and a positron. It is conceptually simpler than hydrogen, which usually is cited for its fundamental simplicity, since hydrogen consists of an electron and a proton (plus 0 to 2 neutrons, in its isotopes). In the vernacular of the nuclear physicists, positronium contains no baryons; its particles are the lightest non-photonic particles known. The simplicity is clear but deceiving. It is, in fact, the great mass of the proton (1836 times as massive as the electron) which permits the use of ordinary quantum mechanics or, if necessary, Dirac formulation for hydrogen. This permission is denied in positronium and the full use of QED is required. Conversely, positronium is an ideal testing ground for the use of QED. Accordingly, investigators have sought, rather vainly, for evidence of excited states of positronium ($n=2,3...$) to parallel the well-known excited states of hydrogen and ordinary atoms. In 1975, Canter, Mills, and Berko reported the observation of the $n=2$ state. Their success was directly due to their previous work in which they developed a new, more effective, technique for

producing positronium by bombarding solid targets with slow positrons. More than one attender suggested that Berko's work in p.a. should be reviewed by the Nobel prize committee.

Here we give a brief enumeration of p.a. methods, followed by some highlights and impressions, leaving a more detailed presentation to an ONRL Conference report now in preparation.

A positron lives in a hostile world dominated by a vast population of electrons. The encounter between a positron and an electron is fatal, resulting in the annihilation of both and the (usual) emission of two photons (occasionally three). The most general technique in use is to obtain positrons from (Na^{22}), a nucleus which is naturally radioactive and emits them. A 1.28-MeV photon is emitted simultaneously and serves the experimenter as a timing marker. In the most common technique employed, the time between this first photon and the subsequent two annihilation photons is measured. In "free space" the lifetime of positronium is long--about 140 ns. In most--but not all--materials being investigated, the lifetime is reduced almost a thousandfold on account of the high concentration of electrons in these materials; therein lies some of the rationale for using p.a. in investigating electronic structure in materials. Furthermore, the annihilation process provides information in itself. The annihilation of a positron and an electron in free space, with both particles at rest prior to the annihilation, should result in the emission of two gamma rays with equal energy (511 keV) and opposite momenta. In fact, the small deviation from emission in opposite directions (a few mrad) is a further source of information; the method is generally entitled angular correlation. Finally, the emitted gamma photons are Doppler-broadened in the emission process, giving rise to a line shape that can be further analyzed.

Positron physics. As just indicated, this is an active field. New observations can be anticipated which should be of great interest to QED ers. I suspect, however, that the impact of these activities for those who use positrons as probes will be small. For them, the positron is a well-established particle.

Positrons in gases. This area appears to be something of a plateau. Experimental efforts center largely on greater precision; theoretical work is largely devoted to rather conventional calculations of cross sections for positron scattering and of positron lifetimes. The thrust of these lies in atomic physics, and I find little evidence that great advances in that area are forthcoming in the near future. However, the implication of these measurements for the behavior of positrons in more condensed systems is exciting. For example, P. Hautojarvi *et al.* (Helsinki University of Technology) reported that the lifetime of orthopositronium in liquid He^4 and He^3 was found to decrease from 100 ns to 50 ns as the pressure was increased to 60 atm. The results are explained by the formation of positronium bubbles, varying in size with pressure from 14Å to 7Å. Most interesting, atoms are observed to cluster about free positrons in He^3 but not in He^4.

Metals. The emphasis here is still on the determination of Fermi surfaces, a subfield that is now reasonably old in itself. To a large extent, the actual accomplishments have been minimal. Perhaps the greatest accomplishment was the demonstration, via p.a., that the Fermi surface is truly sharp. With the recent advances in p.a. technology, it is entirely likely and probable that Fermi-surface investigations will now move ahead rapidly. The most significant new development which promises to spark this next move is the installation of "two-dimensional" angular correlation systems, in contrast with current one-dimensional systems. Leading this move are Steward and Berko; several European groups are moving ahead, also.

Alloys. Several types of investigation fall under this classification: shifts in the Fermi surface with alloying, because of varying electron/atom concentrations; alloy phase changes; amorphous alloys; order-disorder alloys; and hydrogen-bearing systems. The work is in the more elementary stages and the work of M. Doyama and collaborators (University of Tokyo) sets the pace. They have "skimmed the cream" with amazing success. Some of their stimulating observations are these: (a) Alloys display different angular correlation characters depending on which class they belong to; a discontinuous change is found at transition temperatures in beta Cu-Zn, Cu-17 a% Pd, and Cu-22 a% Pd, whereas a continuous change is observed in $AuCu_3$ and

Cu-40 a% Pd. A third class, consisting of Cu-25 a% Pd, Cu-30 a% Pd and Cu-15 a% Mn, corresponds to order/disorder transitions with lattice transformations. (b) Martensitic transformations in Au-Cd are marked by hysteresis, with pretransformation indications. Doyama *et al.* suggest that positron coupling with soft modes is at work here. (c) the lifetime of positrons in amorphous $Pd_{0.775}Cu_{0.06}Si_{0.165}$ is not greatly different from the lifetime in the crystalline state, implying that vacancies in amorphous materials are similar in size to those in crystalline materials and that ion motion in amorphous materials is significantly more restricted than in liquids. (d) Positron annihilation results in a series of metals, which when plotted as a function of electron density, fall onto two straight lines--Li, Na, K, Rb, Cs, and Mg, all of which are hydride-formers; Zn, Cd, Al, In, Sn, Pb, Cu, Ag, and Ni, elements which dissolve hydrogen to a very limited extent.

Self-trapping. Much of the information in p.a. in condensed materials comes from the fact that positrons find refuge in regions where the high concentration of electrons normally present is reduced. Considerable interest, however, exists in cases where it appears that a positron can trap itself. The theory of "self-trapping" has been developed most vigorously by A. Seeger (Stuttgart) and centers about experiments in cadmium. Self-trapping manifests itself apparently in the temperature-dependence of p.a. The nature of the coupling of a positron with the phonon field remains unsettled. Seeger and coworkers describe the coupling through localized, self-trapped positron configurations which are metastable with respect to Bloch-wave positron states; these localized states arise from the deformation potential set up by lattice vibrations. S.W. Tam (Argonne National Laboratory) considered a model in which thermal fluctuations introduce quasi-vacancy structures into the lattice, and treated the probability of the requisite thermal fluctuations by thermal activation analysis coupled with percolation theory. He concludes that this simple mechanism is inadequate. The experimental results of S.M. Kim and W.J.L. Buyers (Chalk River) point to a region of localization whose diameter is large--8 Å.

Defects in Metals. This is clearly one of the most active areas. The original and prevailing basis for interest lies in the localization of positrons in vacancies in metals--positions in which an atom (more correctly, an ion) is missing, an occurrence which increases with frequency at elevated temperatures and is fundamental to most materials-processing methods. Now p.a. has provided another much needed tool to investigate these defects and related defect structures with the particular advantage that it is sensitive to smaller concentrations of vacancies than previous techniques. Since vacancies are also products of irradiation damage and plastic deformation, the interest in p.a. is very wide. Papers at the conference covered the entire field, as evidenced by the following selected examples: the formation energies of a vacancy in pure metals and alloys (M. Doyama); vacancy enthalpy in aluminum (M.J. Fluss *et al.*, Argonne National Laboratories); vacancy binding energies in alloys (W. Triftshauser and Jank--Munich and Jülich); Stage III migration in molybdenum (K. Petersen--Lyngby, Denmark); defect signatures in irradiated metals (W.B. Gauster--Sandia Labs, New Mexico); positron probing of engineering alloy substructures (J.P. Wallace *et al.*--Harwell, England and Risø, Denmark); irradiation-produced voids--a very heavily pursued topic, currently (V.W. Lindberg and J.D. McGervey--Case Western U.; D. Segers *et al.*--Rijksuniversitet, Ghent, Belgium; P. Hautojarvi *et al.*; Thrane *et al.*--Lyngby, Denmark); interactions of dislocations and impurities (Hautojarvi *et al.*). It is clear that p.a. will be heavily used for some time in this area; the surface has been barely scratched.

The fatigue work of Byrne *et al.* gives an indication of the potential technological applications. More specific applications were provided by P.S. Takhar (Royal Military College, Ontario). The utility of p.a. for NDT and related techniques is not simple and bears watching.

Inorganic Solids (Non-Metals). The investigations here parallel those in metals but because of the substantial number of diagnostic tools already available the effort is lower. Lifetime measurements in AgBr were reported by H. Surbeck (ETH, Zurich)

and in CoO, by N. Tsuda *et al.* (National Institute, Kurakake, Japan), for example, to elucidate defect structures.

There is one significant area in which studies in inorganic solids differ from those in metals--an intriguing one, at that. Recall that the life time of positronium in free space is about 140 ns. Apparently positronium formation is absent in metals because of the abundance of electrons there. Perhaps surprisingly, positronium formation does occur in materials such as MgO and SiO_2 powders. D.W. Gidley *et al.* (U. of Michigan) find that the lifetime of positronium, plotted as a function of the bulk density of SiO_2 powder, extrapolates to a value almost the same as the free-space positronium value--but significantly lower by about 2%. These results might be rationalized by speculating that the core electrons are unavailable to positrons and that the valence electrons in SiO_2 are covalently coupled and therefore also unavailable. But this explanation apparently fails since positronium is not observed in silicon, for example.

Chemistry. This is another burgeoning field of p.a. A good deal of discussion concerned three models dealing with positronium formation and inhibition in organic materials. The earliest, the hot positronium model, was built on the radiation chemist's experience with hot electron models for radiation effects in organics. A more recent model, due to Ore, introduced the concept of an energy gap. O.E. Mogensen (Risø, Denmark), in a review paper, presented a third theory--the spur model which is closely associated with work performed by him and his collaborators. This model appears to me to be qualitatively similar to the models used by investigators of irradiation effects in non-organic materials but introduces also such concepts as solvated and dry electrons. Ore rose in his own defense, thereby enlivening the proceedings. A middle course was steered by V.I. Goldanskii (Moscow) in his talk, the last of the conference, suggesting that each model is appropriate in different situations. Nevertheless, we can anticipate further debates on this in the future.

Two of the most stimulating papers were applications of p.a. to biology. Y-C Jean and H.J. Ache (Virginia Polytechnic Institute, Blacksburg) measured the formation constants for a series of molecular complexes of vitamin K_1 and tocopherol with amine and other donors. E.C. Handel *et al.* (North Dakota State University, Fargo) investigated the relationship between positron lifetime and protein structure and reported the effect of temperature, pH, concentration and ligand binding on positron annihilation parameters in two model proteins. This information together with x-ray crystallographic data provides the basis of models for protein structure-function relationships and protein conformations in solution. Both investigations are clearly pioneering in nature and presage still another subfield in p.a.

The life of the positron may be fleeting, indeed, but the positron's service to science appears to be growing prodigiously. (A. Sosin)

NEWS & NOTES

A.B. WOOD MEDAL & AWARD

Professor R. Dobbs, President of the Institute of Acoustics (UK) announced at the Institute's Autumn Conference that P.A. Crowther of the Marconi Space & Defence Systems Ltd. (Naval Division) Frimley, UK, has been selected as the next recipient of the A.B. Wood Medal. This award is made to a citizen of the US or UK under 35 for distinguished work in physical sciences associated with the sea and particularly underwater acoustics.

Crowther is well known for his contributions to knowledge of underwater acoustic reverberation. He recently prepared a valuable review article on "Surface Wave Spectra" for a NATO Saclant ASW Research Centre Conference on Oceanic Acoustic Modelling (Saclantcen Conf. Proc. No. 19 Pt 3 Oct. 75).

The award will be made at the Institute's Spring Conference to be held at the University of Bath on 4-6 April 1977, when topics will include a specialist session on underwater acoustic studies of sediments.

FORTHCOMING SUMMER SCHOOL

The University of Grenoble and the NATO Study Institute Programme are sponsoring the 30th Session of the Ecole d'Eté de Physique Théorique's

Summer Schools which will be held at Les Houches (French Alps) 4 July-20 August. The title of this forthcoming session is "Nuclear Physics with Mesons and Heavy Ions." The deadline for applications is 15 March. Further information may be obtained from Ecole d'Eté de Physique Théorique, 74310 Les Houches, France.

ONRL NEWS

Dr. Nelson M. Blachman, GTE Sylvania Electronics Defense Laboratory, Mountain View, CA, joined our staff of Liaison Scientists on 1 October. He will be covering electronics and its related fields for the office.

News has recently been received of the death on 6 May of Professor Leo Katz, Department of Statistics and Probability, Michigan State University, East Lansing. Dr. Katz was a Liaison Scientist for Mathematical Statistics with ONRL from August 1959 to August 1960.

PERSONAL

The Gold Medal of the Centre National de la Recherche Scientifique (CNRS) has been conferred upon Professor Henri Cartan for the year 1976. In 1969 Cartan was named Professor of the Faculty of Sciences of Orsay and became the first President of the University of Paris-Sud, Orsay, where he taught until 1975. Cartan's numerous works cover the funcions of several complex variables, analyses and topology. He was one of the founders of the *Groupe Bourbaki*, whose members have published the treatise, *Elêments de Mathematiques*. He is also the co-author of *Homological Algebra* which is considered a classic in the mathematics field.

The French Council of Ministers has announced the appointment of Mr. Hubert Curien as President of the Council of Administration of the Centre National d'Etudes Spatiales (CNES). Curien, who has been general delegate to the Recherche Scientifique et Technique since 1973, succeeds Maurice Levy who has been the head of CNES for the past three years. Curien's research field is in crystallography and the physics of solids.

Dr. M.J. Delaney, Senior Lecturer in Biology and Vice-Chairman of the Board of Studies in Environmental Sciences at the University of Southampton, has been appointed to the Chair of Environmental Sciences at the University of Bradford.

At the University of Aston (Birmingham), Dr. I.L. Dillamore has been appointed Professor and Head of the Department of Metallurgy and Materials, and Dr. K. Forster, has been appointed Professor and Head of the Department of Mechanical Engineering.

Dr. E. Edwards has been appointed Professor of Applied Psychology at the University of Aston in Birmingham.

The following have been appointed members of the Natural Environment Research Council: Mr. H. Fish, Director of Scientific Services, Thames Water Authority; Dr. M.W. Holdgate, Director-General of Research at the Department of Environment; Professor E. Naylor, Director of the Port Erin Biological Station and Professor of Marine Biology at Liverpool University; Professor J. Sutton, FRS, Professor of Geology, Imperial College of Science and Technology, University of London; and Mr. G. Williams, Director-General of the United Kingdom Offshore Operators Association.

Dr. Roger Grice, Assistant Director of Research, University Chemical Laboratory, Cambridge, has been appointed Professor of Physical Chemistry from 1 October in succession to Professor Geoffrey Allen.

At the University of Strathclyde, Professor J.M. Harvey, Trades House of Glasgow Professor of Mechanics and Materials in the Mechanical Engineering Group, has been appointed Deputy Principal for three years in succession to Professor E.S. Fairley, Professor of Electrical Engineering, who retired in September. Professor A.M. North, Burmah Professor of Physical Chemistry, became Vice-Principal for two years in succession to Professor S.G.E. Lythe, Professor of History, who also retired in September.

At City University (London), Dr. P. Herriot, Reader in Psychology, has been appointed to a Chair of Psychology with effect from 1 October.

Professor D.S. Jones, FRS, Professor of Mathematics at the University of Dundee, has been appointed a member of the University Grants Committee for five years.

Professor J.B. Lloyd, Head of the Research Unit in Biochemistry at Keele University, has been promoted to the established Chair of Biochemistry from 1 October.

Dr. W.W. Macdonald, Reader in the Liverpool School of Tropical Medicine, has been appointed to the Chair of Medical Entomology at the London School of Hygiene and Tropical Medicine from 1 January 1977.

Dr. C. Mortimer, Reader in Chemistry at Keele University, has been promoted to a personal Chair of Inorganic Chemistry from 1 October.

At the University of Aberdeen, Dr. Derek Ogston, Reader in Medicine, has been appointed to the Regius Chair of Physiology.

At the University of Reading, the title of Emeritus Professor has been conferred on Professor Cyril Tyler, who recently retired as Professor of Physiology and Biochemistry and as Deputy Vice Chancellor. Professor E.W.J. Mitchell, Head of the Department of Physics, has been appointed Deputy Vice Chancellor for 1976-80.

OBITUARIES

Professor Charles Dent, FRS, Professor of Human Metabolism at University College Hospital Medical School, London, since 1956, died on 19 September, at the age of 65. Dent had a varied training. Starting as a bank clerk, he graduated in chemistry in 1931 and worked in the dye industry until 1937 when he started studying medicine. This was interrupted by the war, and he received his medical degree in 1944. It was the discovery of chromatography that gave Dent, already a chemist and a doctor, his chance to practice in new fields. He improved the methods of separating amino-acids by chromatography and identified new amino-acids in the urine of patients and unravelled the biochemical mechanisms behind a number of diseases, particularly those associated with mental defect. But for his efforts, mental defect would not be curable in some instances as it is today.

The distinguished German spectroscopist, Professor Heinrich Kaiser, died 23 August at the age of 69. He made decisive personal contributions to spectrochemical analysis, particularly in relation to the theory of errors and limits of detection; and as Director of the Institute for Spectrochemistry and General Spectroscopy at Dortmund, from its foundation in 1952 until very recently, his strong leadership ensured continuing valuable contributions to the science and art of spectroscopy.

Professor Leopold Ruzicka, joint recipient with Adolph Butenandt of the 1939 Nobel Prize for Chemistry, died in Zurich recently at the age of 89. His share in the Prize came for his work on ringed molecules and higher terpenes, a class of hydrocarbons found in the essential oils of many plants. Ruzicka's discovery that the compounds muskone and civatone, both important to the perfume industry, had molecules with a far higher number of atoms in their rings than had been thought possible, sparked off a minor revolution in the chemistry of ringed molecules which, in turn, provoked a great deal of research on these compounds.

CORRECTION

A typographical error in the article on the SHAPE Technical Center by D. Cheng (ESN 30-8:363) resulted in the designation of Dr. J.S. Burgess and his prospective replacement I. Mirman (USAF Systems Command, Andrews AFB) as Director, SHAPE Technical Center. The correct title of the position is Deputy Director. Dr. F.E.W.A. Wiekhorst is Director of the Center. We apologize to the above-named individuals and to our readers for this error.

ONRL REPORTS

R-7-76 AN INDUSTRIAL TECHNOLOGY CALLED TRIBOLOGY--THE UK EXPERIENCE AND ITS IMPLICATIONS by R.H. Nunn and H. Herman

Tribology, defined as the science and technology of interacting surfaces in relative motion and of related subjects and practices, is the result of a series of UK activities, begun in 1966, to provide remedies to certain industrial ills. This report, intended for the general reader, is an overview of the birth, growth, and present state of tribology in the UK. The actions of the Committee on Tribology are discussed, as well as those of the Tribology Centres and other UK organizations concerned with lubrication and wear. Relevant but broader issues are also discussed. These include the interdisciplinary approach, effective communication between academia and industry, and the concept of industrial technologies. Comments are offered concerning the lessons to be learned from the UK experience. Appendices provide brief descriptions of the proposed education module in tribology, the symposium titled "Tribology 1976," and the practice of lubrication analysis including ferrography.

R-8-76 MATERIALS RESEARCH IN COPENHAGEN AND ENVIRONS by H. Herman

Three materials science activities in Denmark were visited to update a report written by another liaison scientist some nine years ago. Two of the institutions are academic, The Technical University of Denmark at Lyngby, a suburb of Copenhagen, and the other directly in town, at the University of Copenhagen. A government laboratory was visited as well, The Research Establishment Risø, located north of the city. The development of science, especially materials science, in the midst of the evolving influences of social democracy, is discussed.

R-9-76 HIGHLIGHTS OF DYNAMICAL CLIMATOLOGY IN EUROPE by A.I. Barcilon

This report is divided into two main parts. The first deals very briefly with the broad questions raised by the modeling of climatic changes and should provide the non-initiated in this field with some ideas of the problems involved. The second part of the report focuses on some of the work in dynamical climatology (i.e., the numerical or theoretical modeling of climate changes) as is presently found in Europe. The survey does not pretend to be exhaustive and has been limited to modeling in which the time scale considered is monthly, seasonal or yearly.

C-22-76 THERMOMETRY AND TEMPERATURE SCALES: THE INSTITUTE OF PHYSICS LONDON MEETING IN JUNE 1976 by T.A. Kitchens, Jr.

A review of a one-day (4 June 1976) meeting of the Low Temperature of the Institute of Physics in London on Thermometry. Discussions included mK adjustments in the near 4 K range, platinum resistance thermometry up to 273 K and fixed point superconducting thermometry.

C-23-76 4TH INTERNATIONAL CONGRESS ON MARINE CORROSION AND FOULING by H. Herman and E.C. Haderlie

This 4th International Congress on Marine Corrosion and Fouling at Juan-les-Pins, France, conference was attended by a wide range of specialists concerned with the behavior of materials in the sea. Broadly, two areas of concern were treated in two simultaneous sessions: (1) corrosion and corrosion-related topics, and (2) fouling. The deterioration of materials, either due to their demise electrochemically or due to their being used as a habitat for a variety of biota, is a central activity of the navies and maritime organizations of the world. Some 250 attendees came to the south of France during June to exchange notes on these very important topics.

C-24-76 NUCLEAR ORIENTATION STUDY by T.A. Kitchens, Jr.

In mid-July 1976, a European Study Conference on Low Temperature Nuclear Orientation was held in Oxford. The conference concentrated on techniques and brief summaries of the state-of-the-art. The techniques covered were adiabatic demagnetization, dilution refrigeration, brute force orientation, ion implantation, recoil implantation, γ-ray anisotropy and radiative detection of nuclear magnetic resonance of oriented nuclei. The understanding gained by these techniques of the nuclear decay schemes, nuclear dipole and quadrupole moments, nuclear level assignments, parity and time-reversal violations, metallurgy, magnetic order, relaxational effects, and the Kondo and spin glass phenomena was reviewed.

C-25-76 THE ISRAELI-AMERICAN INTERNATIONAL CONFERENCE ON APPLIED METALLURGY by H. Herman

This joint ASM-IMS meeting on applied metallurgy was attended by a good representation of academia and industrial scientists and engineers. A wide range of topics was covered; from non-destructive evaluation, joining, failure analysis, to electronic materials. The diversity and sophistication of interests shown by the Israeli indicated that theirs is a growing and forward-thinking industry, and that joint international conferences like this one are in fact mutua-ly beneficial.

C-27-76 EIGHTH INTERNATIONAL SYMPOSIUM ON THE REACTIVITY OF SOLIDS by P.J. Herley

The Eighth International Symposium on the Reactivity of Solids was held at Chalmers University of Technology, Gothenburg, Sweden 14-19 June 1976. The conference focused on six major aspects of the reactivity of solids: Reaction at surfaces and interfaces, especially at elevated temperatures; the influence of structural defects on reactivity; solid state reactions in organic materials; reactions in vitreous solids; the role of solid state reactions in materials technology.

C-28-76 SOLID-VACUUM INTERFACES by T.A. Kitchens, Jr.

This report briefly recounts the highlights of the Fourth International Symposium on Surface Physics held at the Technische University of Technology on 23-25 July 1976. The emphasis of the meeting was on Solid-Vacuum interfaces. Six invited papers were given, most of which were discussions of recent advances in understanding the analytical techniques used in surface science.

C-29-76 THEORETICAL POLYMERS by T.A. Kitchens, Jr.

This report summarizes the papers presented at the two-day UK Institute of Physics conference on theoretical methods in polymer physics. The meeting was held at the University of Leeds 5-7 July 1976 and about twenty papers were presented on the excluded volume model, various treatments of the entanglement problem, the glassy and collapse transition, and the use of the renormalization group methods.